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ANCIENT EGYPTIAN MATERIALS & INDUSTRIES

BY

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SECOND EDITION, REVISED

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‘Is there any thing whereof it may be said,
See, this is new? it hath been already of old
time, which was before us.’

Ecclesiastes, i. 10.



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PREFACE TO SECOND EDITION

The kind reception accorded to the first edition of *Ancient Egyptian Materials* has encouraged the author to venture on what in one sense may be considered a second edition, though in another sense it is practically a new work, as it has been so much altered and enlarged. The title, too, has been changed to *Ancient Egyptian Materials and Industries*, the ancient industries, only occasionally mentioned in the first edition, being now treated of at considerable length.

The matter has been so much increased that there are fifteen chapters in place of the original twelve, the fresh material including, not merely more information about the subjects previously dealt with (the description of which has been rewritten, rearranged and considerably expanded), but also a number of additional subjects, the principal of which are : alcoholic beverages ; alum ; basketry ; brushes ; charcoal ; coral ; cordage ; cosmetics ; feathers ; glue ; hair ; incense ; matting ; mother-of-pearl ; perfumes and sugar, as also the industries of brewing ; faience making ; glass making ; metal working ; mining ; pottery making ; quarrying ; stone working and wine making.

A greater use than in the first edition has been made, not only of the ancient Egyptian records, but also of the works of the ancient Greek and Latin writers, where the latter refer to Egypt, and an endeavour has been made to present briefly what is known from these sources about the subjects dealt with.

The chemical analyses, again relegated to an appendix, have been rearranged and greatly augmented.

Although the author has pointed out what he believes to be certain mistakes that occur in the literature of Egyptology and has expressed definite opinions on various disputed matters, he

has endeavoured to bear in mind the precept of Robert Boyle that 'a man may be a champion for truth without being an enemy to civility; and may confute an opinion without railing at them that hold it'¹ and he would add in the words of Leeuwenhoek: 'As I aim at nothing but Truth, and so far as in me lieth, to point out Mistakes that may have crept into certain Matters; I hope that in so doing those I chance to censure will not take it ill; and if they would expose any Errors in my own Discoveries, I'd esteem it a Service; all the more, because 'twould thereby give me Encouragement towards Attaining of a nicer Accuracy.'²

A. L.

¹ *The Sceptical Chymist*, 1661.

² A. van Leeuwenhoek, *Letters*, 1632-1723.

PREFACE TO FIRST EDITION

It is only in comparatively recent years that the chemist has been consulted by the archæologist and has been given an opportunity of examining antique objects, and up to the present little more than preliminary work has been possible and a considerable amount of detailed systematic analysis still remains to be done, and a number of problems in Egyptology that chemistry alone can solve will be found indicated in the present book.

Any consideration of ancient Egyptian materials to be of value should include a description of each material dealt with, its nature or composition, its use and, whenever possible, its place of origin and the date when it was first employed. These particulars the author has attempted to supply, and where there is no certain knowledge he has refrained from speculation.

Information concerning some of the materials is contained in the ancient records, but the author has ventured to disregard this almost entirely, not because he underrates the historical value of the records, but because they are not suitable for the purpose he has in view, which is to establish certain facts by scientific evidence only, whereas the statements made in the records are often vague or their meaning uncertain and, at the best, can only have been second-hand originally and may be wrong or misleading, and the act of translation may introduce further errors or misconceptions.

The information regarding the nature and composition of the materials has been obtained from a personal examination and analysis whenever possible, or, when this has not been possible, from the published analyses and descriptions of others. The information concerning the sources of the materials has been derived from a knowledge of the mineral resources of the

country and from the reports of the Geological Survey of Egypt and of the Department of Mines and Quarries. The dating of the materials has been taken from archæological reports and museum catalogues.

It is realized that the matter presented is only part of a many-sided subject, but it is hoped that not only may it be found interesting in itself, but that it may help to a better understanding of the other sides of the same subject.

In the identification of ancient Egyptian materials mistakes have frequently been made in the past, and these mistakes are reproduced from one book to another without inquiry or verification until many of them have been so often repeated as now to be accepted without question. As far as possible such mistakes will be pointed out and corrected.

When Egypt is stated to be the place of origin of any material the geographical limits of modern Egypt are meant, which include Sinai and which extend from the Libyan desert on the west to the Gulf of Suez and the Red Sea on the east, as far south as the Sudan frontier. It is realized that this territory embraces Lower Nubia (from Aswan to Wâdi Halfa), which was not always a part of Egypt, but any other arrangement would have depended upon the frequently expanding and contracting southern border of ancient Egypt and would often have been uncertain and frequently misleading.

The friends who have helped with information, suggestions and materials for analysis are too numerous to allow of their being mentioned separately by name, though this is done in the text whenever possible, but to all of them the author wishes to tender his thanks.

In order not to encumber the text, the details of the chemical analyses have been placed in an Appendix.

A. L.

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ANCIENT EGYPTIAN MATERIALS & INDUSTRIES

INTRODUCTION

For the full understanding of ancient Egyptian materials and industries some slight knowledge at least of the history of the country is necessary in order that the great antiquity of the civilization and the remote dates at which many of the materials were used and many of the industries practised may be realized. A brief historical outline, therefore, will be given.

Fossil remains of primitive man have not been discovered so far in Egypt, the earliest evidence of human habitation of the Nile valley being certain stone weapons and implements (principally of flint) that have been found in large numbers in various parts of the country. With these their owners could hunt and fight, but that is all that is known about them, since neither their habitations nor their graves, if they had either, have been found. These shadowy Egyptians are called the Old-Stone Age (Paleolithic) people and they were simply hunters following the animals they lived on about the country, that is, they were food gatherers and not food producers and subsisted on the results of the chase and on the fruits, seeds, plants and roots they found growing wild. Immediately succeeding them came the New-Stone Age (Neolithic) Egyptians, who until recently were equally unsubstantial, but whose stone weapons and implements were of a more advanced type than those of their predecessors. Of these later people, settlements and cemeteries have now been discovered,^{1, 2, 3} which prove that although

¹ P. Bovier-Lapierre, *Une nouvelle station néolithique, au nord d'Hélouan*, in *Compte rendu du Congrès internationale de Géog.*, Le Caire, 1925, IV (1926), pp. 268-82.

² G. Caton-Thompson, *The Neolithic Industry of the Northern Fayum Desert*, in *Journ. Royal Anthropol. Inst.*, LVI (1926), pp. 309-23; *Explorations in the Northern Fayum*, in *Antiquity*, I (1927) pp. 326-40; *Recent Excavations in the Fayum*, in *Man*, XXVIII (1928), 80; *The Royal Anthropol. Inst. Prehistoric Research Expedition to Kharga Oasis, Egypt*, in *Man*, XXXII (1932), 158.

³ H. Junker, *Merimde-Benisalâme*, 1929, 1930.

they were still in the Stone Age, that is without any knowledge of the use of metals, they were no longer merely food gatherers, but food producers and that they practised agriculture; domesticated animals; made pottery; wove fabrics; plaited baskets and mats; made bone, as well as stone, implements; made shell and stone beads and fashioned small vases out of such a very hard stone as basalt.^{1, 2}

The Stone Age was followed by a period of unknown duration, at the commencement of which came the dawn of the knowledge of metals when copper and gold were employed occasionally for small articles of personal adornment and which ended with a greater use of gold, a slight use of lead and silver and a considerable use of copper for weapons, tools and household utensils. This period includes the Badarian civilization and the early, middle and late Predynastic periods, during which time the country was split up into a number of petty states, from the chaos of which gradually emerged two kingdoms, one of the North or Lower Egypt (Delta) and the other of the South or Upper Egypt. Nothing certain is known about either the separate states or the two kingdoms, beyond the fact of their existence and that almost certainly the Delta was more advanced in civilization than Upper Egypt, and the practical commencement of Egyptian history dates from about 3400 B.C. when Menes from Thinis near Abydos in Upper Egypt conquered the Delta and welded the country into the united kingdom of Egypt.³

The historical period is divided for the sake of convenience into thirty Dynasties, each of which corresponds to a different royal House, analogous to the divisions of English history into the Houses of Normandy, Plantagenet, Tudor, Stuart, Hanover, and so on.

So little is known about the first two Dynasties that they are frequently either classed together as Protodynastic, or

¹ G. Caton-Thompson, private letter dated Feb. 1st, 1930.

² H. Junker, *op. cit.*, 1929, p. 223.

³ There had probably been a previous union of the North and South brought about by a conquest of Upper Egypt by the Delta king, but this did not last (J. H. Breasted, *The Predynastic Union of Egypt*, in *Bull. de l'Inst. franc d'arch. orientale*, xxx (1931), pp. 709-24).

grouped with the late Predynastic period, the whole being called Archaic.

With the Third Dynasty began the Old Kingdom or Pyramid Age, as it is sometimes called, which lasted until the end of the Sixth Dynasty.

The period from the Seventh Dynasty to the Tenth Dynasty inclusive was one of internal conflict and is very obscure. This is known as the First Intermediate period.

The Eleventh and Twelfth Dynasties constitute the Middle Kingdom or Feudal Age, a time of great prosperity.

From the Thirteenth Dynasty to the Seventeenth Dynasty inclusive was a period of disorganization, about which present knowledge is very scanty, except that it included an interval of foreign domination under the Hyksos kings. This is the Second Intermediate period.

The Eighteenth Dynasty ushered in the New Kingdom or Empire, which lasted until the end of the Twentieth Dynasty, during which time Egypt conquered the countries now known as Palestine and Syria respectively and became a great power in western Asia.

In the Twenty-first Dynasty the Empire fell to pieces.

Of the next four Dynasties, the Twenty-second to the Twenty-fifth inclusive, very little is known, except that during part of the time the country was under the domination first of the Ethiopians and later of the Assyrians.

In the Twenty-sixth Dynasty there was a revival of independence and prosperity, which was followed by the Persian conquest and the period from the Twenty-seventh Dynasty to the Thirtieth Dynasty inclusive was one of Persian domination, except for brief intervals when the Egyptians gained temporary independence.

After the conquest of the Persians in Asia by the Greeks, Alexander the Great took possession of Egypt and the Greek domination under his successors, the Ptolemies, lasted until Egypt became a Roman province, the country then remaining in Roman occupation until the Arab conquest.

As may be seen from the above short summary, there are several periods of Egyptian history, lasting in some cases two or three hundred years, about which very little is known, and

even of the periods that are better known the information is very partial. With such gaps in the existing knowledge a final statement regarding the earliest or latest production or use of any material is impossible, and all that can be done is to give the dates for which the various materials have been recorded.

CHRONOLOGICAL SUMMARY

<i>Period</i>	<i>Dynasty</i>	<i>Approximate Date</i>
Stone Age	{ Paleolithic Period	Undated
	{ Neolithic Period	Possibly ended about 5000 B.C.
Predynastic	{ Badarian Civilization)	} 5000 to 3400 B.C.
	{ Early Predynastic	
	{ Middle Predynastic	
	{ Late Predynastic	
Protodynastic	I and II	3400 to 2980 B.C.
Old Kingdom	III	2980 to 2900 B.C.
	IV	2900 to 2750 B.C.
	V and VI	2750 to 2475 B.C.
First Intermediate Period	VII to X	2475 to 2160 B.C.
Middle Kingdom	XI and XII	2160 to 1788 B.C.
Second Intermediate Period ¹	XIII to XVII	1788 to 1580 B.C.
New Kingdom or Empire {	XVIII	1580 to 1350 B.C.
	XIX	1350 to 1200 B.C.
	XX	1200 to 1090 B.C.
Period of which little is known ²	XXI to XXV	1090 to 663 B.C.
Late Egyptian Period . .	XXVI	663 to 525 B.C.
Persian ³	XXVII to XXX	525 to 332 B.C.
Greek (Ptolemaic)	—	332 to 30 B.C.
Roman ⁴	—	30 B.C. to A.D. 640
Arab	—	A.D. 640

¹ Includes the period of Hyksos domination.

² Includes a lengthy period of Ethiopian rule and a short period of Assyrian domination.

³ Includes a brief period of Egyptian rule in the Thirtieth Dynasty.

⁴ Includes the Byzantine period.

CHAPTER I

ALCOHOLIC BEVERAGES AND SUGAR

The alcoholic beverages of ancient Egypt were of two kinds, namely, beer and wine.

BEER

For an understanding of the nature and mode of preparation of ancient Egyptian beer, some knowledge of the underlying principles of brewing is necessary and, therefore, modern beer and its manufacture will very briefly be described.

Modern beer is essentially an infusion of malt, flavoured with the bitter of hops and fermented with yeast : it usually contains from about 2 to about 6 per cent of alcohol by volume.

When barley, or other farinaceous grain, germinates, an active nitrogen-containing substance termed an enzyme (of which there are many kinds, the particular one now referred to being known as diastase), which is naturally present in the grain in small proportion, increases considerably in amount and converts a small part of the starch of the grain into a particular kind of sugar called maltose and a gummy material termed dextrin, the former of which becomes the food supply for the growing plant in its early stages. Malting is the reproduction of this natural process under conditions that can be controlled, the grain being first exposed to moisture and warmth until it germinates and then being heated to arrest further growth, in order that the sugar (maltose) formed may be conserved : the resulting product is termed 'malt.'

After malting comes brewing, in which there are three main processes, namely, (a) maceration of crushed malted grain, or of a mixture of malted and unmalted grain, in hot water, during

which the diastase present converts that part of the starch of the grain, not previously acted upon, into maltose and dextrin ; (b) boiling the solution extracted from the grain with hops, so as to flavour it, and (c) fermentation of the solution with yeast, which first of all, by means of an enzyme termed maltase, converts the maltose into another kind of sugar called dextrose (maltose not being directly fermentable by yeast), which is then split up by still another enzyme (zymase) into alcohol and carbon dioxide gas, the alcohol and part of the gas remaining dissolved in the liquid. The essentials of brewing, therefore, are the conversion of the starch of a cereal grain into sugar and the subsequent change of this sugar into alcohol and carbon dioxide.

As a further preliminary to the description of ancient Egyptian beer, a beer called *bouza* made at the present day in Egypt by Nubians may be described. Sixteen different specimens of this *bouza*, purchased from retail dealers in Cairo, were examined : they were all similar and had the appearance of thin gruel : they contained much yeast, were in a state of active fermentation and had been made from coarsely ground wheat : the amount of alcohol present varied from 6.2 per cent to 8.1 per cent by volume, with a mean of 7.1 per cent.

Inquiries elicited the information that in Cairo *bouza* is prepared as follows, though doubtless there are variants of the method :

1. A good quality of wheat is taken ; the dirt and foreign material are picked out and the wheat is coarsely ground.

2. Three-quarters of the ground wheat are put into a large wooden basin or trough and kneaded with water into a dough, yeast being added.

3. The dough is made into thick loaves, which are baked, though only lightly, so as not to destroy the enzymes or to kill the yeast.¹

4. The remaining quarter of the wheat is moistened with water and exposed to the air for some time, after which, while still moist, it is crushed.

5. The loaves are broken up and put into a vessel with water and the crushed moist wheat added : the mixture ferments on account of the yeast present in the bread, though in order to induce a quicker fermentation a little old *bouza* from a previous brewing is often added.

¹ Specimens of this beer-bread were obtained and examined.

6. After fermentation, the mixture is passed through a hair sieve, the solid material being well pressed on the sieve with the hands.

Operation No. 4 is manifestly a primitive and very incomplete form of malting, resembling very closely that described by Zosimos.¹ Malting, however, although general at the present day, is not essential, and at one time it was customary in certain parts of Europe to make beer from unmalted rye. But, as starch is not directly fermentable by yeast and requires to be converted into sugar before fermentation can take place (which is usually brought about by the diastase produced during malting), the fermentation of unmalted grain needs explanation. The same problem presents itself in the fermentation that produces the carbon dioxide to which the rising of leavened bread is due. The explanation is simple. Cereal grains contain a small amount of certain sugars (sucrose and raffinose), which, though not directly fermentable, are converted by one of the enzymes of the yeast (invertase) into dextrose, which, as already explained, is fermentable. In addition, however, there is also a small amount of diastase in the grain, which produces maltose from some of the starch present, this maltose being subsequently converted into dextrose, which undergoes fermentation. Sugars may also be formed from the starch of the grain by means of moulds, which are present on the grain and in the air and of which many 'contain . . . diastase in considerable quantity and are consequently possessed of powerful starch-converting activity,'² and moulds have been utilized in the East from very early times for the conversion of starch into sugar and of sugar into alcohol³ and certain moulds⁴ are

¹ See p. 10.

² A. Chaston Chapman, *Micro-organisms and some of their Industrial Uses*, Royal Society of Arts, 1921, pp. 8-9.

³ In Japan cultures of *Aspergillus oryzae* supply the diastase for the saccharification of the starch of rice and wheat bran used for making alcoholic drinks and in China a mixture of micro-organisms, of which the predominating one is a fungus (*Amyloces rouxii*) belonging to the group of mucors, is employed, not only for the saccharification of starch, but also for the fermentation of the sugar into alcohol (W. L. Owen, *Production of Industrial Alcohol from Grain by Amylo Process*, in *Industrial and Engineering Chemistry*, 25 (1933), pp. 87-9.

⁴ *Amyloces rouxii* and certain special mucors such as *Rhizopus delemar*.

used for saccharification purposes to-day on a very large scale in special methods of preparing alcohol.¹

Lane in 1860 stated² that *bouza* 'which is an intoxicating liquor made from barley-bread, crumbled, mixed with water, strained and left to ferment, is commonly drunk by the boatmen of the Nile and by other persons of the lower orders.'

Burckhardt, writing in 1822, states³ that in Berber (Nubia) *bouza* was made from strongly leavened millet bread, which was broken into crumbs, mixed with water and kept for several hours over a slow fire, after which more water was added and the mixture left for two nights to ferment: he describes the ordinary *bouza* as not being strained and looking more like soup or porridge than a beverage, but mentions a better quality obtained by straining through a cloth: he also says that barley was sometimes used instead of millet and that it produced a superior beer, which was of a pale muddy colour and very nutritious: he further says that in Cairo and in all the towns and larger villages of Upper Egypt there were shops for the sale of *bouza* kept exclusively by Nubians, which is still true to-day.

Bruce in 1805 gave a similar account of the preparation of *bouza* in Abyssinia.⁴

Beer is frequently mentioned in the ancient Egyptian records^{5, 6} as a divine offering, as an oblation, as a mortuary offering and as a beverage, the earliest reference known to the author being one of the Third Dynasty, where a brewery carried on by women is mentioned⁷: the next reference in chronological order that can be traced is from the Fifth Dynasty, where beer is named as a mortuary offering.⁸ Residues, however, of the predynastic period have been found in jars which originally

¹ The Amylo and Boulad Processes.

² E. W. Lane, *The Manners and Customs of the Modern Egyptians*, pp. 96, 342. (Everyman's Library.)

³ J. L. Burckhardt, *Travels in Nubia*, p. 201.

⁴ J. Bruce, *Travels to Discover the Source of the Nile*, vii, pp. 66, 335.

⁵ J. H. Breasted, *Ancient Records of Egypt*, v (Index), p. 108.

⁶ A. Erman, *The Literature of the Ancient Egyptians*, trans. A. Blackman.

⁷ W. M. Flinders Petrie, *Supplies and Defence*, in *Ancient Egypt*, 1926, p. 16.

⁸ J. H. Breasted, *op. cit.*, I, 252.

contained beer that has evaporated.¹ Beer, therefore, is manifestly of very early date.

Beer, as well as having been made in the country, was also imported, though probably only to a small extent and at a comparatively late period, the only references to this that can be found being of New Kingdom date, where beer from Kedi in Asia is referred to.²

Egyptian beer is described by several of the classical writers ; thus Herodotus says³ that the Egyptians 'use a drink made of barley' ; Diodorus states⁴ that they 'make a drink of barley . . . for smell and sweetness of taste not much inferior to wine' ; Strabo says⁵ that 'Barley beer is a preparation peculiar to the Egyptians. It is common among many tribes, but the mode of preparing it differs in each' and that it was one of the principal beverages of Alexandria⁶ ; this same writer also states⁷ that the Ethiopians made a drink both from millet and from barley ; Pliny says⁸ that an intoxicating beverage was made in Egypt from corn ; Athenaeus states⁹ that the Egyptians, who could not afford wine, used an intoxicating drink made from barley. During the Ptolemaic period brewing was a royal monopoly.¹⁰

The brewing of beer is depicted on a number of tomb walls, for example, in a Fifth Dynasty tomb at Saqqâra¹¹ ; in a Sixth Dynasty tomb at El-Deir el-Gebrâwi¹² ; in a Sixth Dynasty tomb at Meir¹³ and in a Middle Kingdom tomb in the Theban necropolis,¹⁴ in each case bread-making and brewing being associated, the former being a preliminary step towards the latter.¹⁵ The explanation of these tomb scenes seems to have

¹ W. M. Flinders Petrie, *Prehistoric Egypt*, p. 43.

² A. Erman, *op. cit.*, pp. 207, 210. ³ II, 77.

⁴ I, 3.

⁵ *Geography*, XVII, 2, 5.

⁶ XVII, 1, 14.

⁷ XVII, 2, 2.

⁸ *Natural History*, XIV, 29.

⁹ *The Deipnosophists*, I, 34.

¹⁰ E. Bevan, *A History of Egypt under the Ptolemaic Dynasty*, 1927, p. 148.

¹¹ G. Steindorff, *Das Grab des Ti*, Pls. 83-4.

¹² N. de G. Davies, *The Rock Tombs of Deir el Gebrâwi*, II, p. 26, Pl. XX.

¹³ A. M. Blackman, *The Rock Tombs of Meir*, IV, p. 35, Pl. XIII.

¹⁴ N. de G. Davies and A. H. Gardiner, *The Tomb of Antefoker and his Wife Senet*, p. 15, Pls. XI, XIIA.

¹⁵ See also (a) H. F. Lutz, *Viticulture and Brewing in the Ancient Orient*, and (b) P. Montet, *La Bière*, in *Les scènes de la vie privée dans les tombeaux Égyptiens de l'Ancien Empire*, pp. 242-54.

been first pointed out by Borchardt.¹ Brewing is also illustrated by various tomb models, thus an Eleventh Dynasty wooden model found at El-Deir el-Bahari shows the operations of corn being ground; dough being kneaded; the 'mash' being made; the solution being fermented and the finished beer being poured into jars.² Similar models of about the same date are described by Garstang.³ It is practically certain, therefore, that both in mode of preparation and in composition the ancient Egyptian beer approximated closely to the modern Nubian *bouza*.

According to a description attributed to Zosimos of Panopolis in Upper Egypt, who lived about the end of the third century or the beginning of the fourth century A.D., and spent his youth at Alexandria, ancient Egyptian beer was made as follows⁴: 'Take well-selected fine barley, macerate it for a day with water, and then spread it for a day in a spot where it is well exposed to a current of air. Then for five hours moisten the whole once more, and place it in a vessel with handles, the bottom of which is pierced after the manner of a sieve.' The meaning of the next few lines is not clear, but according to Gruner the barley was then probably dried in the sun, in order that the husks, which are bitter and which would have imparted a like taste to the beer, might peel off. Continuing the description of Zosimos: 'The remainder must be ground up and a dough formed with it, after yeast has been added, just as is done in bread-making. Next the whole is put away in a warm place, and as soon as fermentation has set in sufficiently, the mass is squeezed through a cloth of coarse wool, or else through a fine sieve, and the sweet liquid is gathered. But others put the parched loaves into a vessel filled with water, and subject this

¹ L. Borchardt, *Ägyptologischen Zeitschrift*, xxxv (1897), pp. 128-31.

² H. E. Winlock, *Bull. Egypt. Exped.*, 1918-20, *The Met. Mus. of Art, New York*, II (1920), p. 26, Fig. 12.

³ J. Garstang, *The Burial Customs of Ancient Egypt*, pp. 63, 73-6, 86, 94, 126-8; Figs. 50, 61, 62, 75, 84, 124-5.

⁴ The translation is that of C. G. Gruner, as given by Arnold (J. P. Arnold, *Origin and History of Beer and Brewing*, 1911). Other translations differ somewhat, for example those of H. F. Lutz (*Viticulture and Brewing in the Ancient Orient*, 1922, p. 78) and of P. Montet (*Les scènes de la vie privée dans les tombeaux Égyptiens de l'Ancien Empire*, pp. 253-4).

to some heating, but not enough to bring the water to a boil. Then they remove the vessel from the fire, pour its contents into a sieve, warm the fluid once more, and then put it aside.'

Although Zosimos describes a primitive method of malting, which is almost identical with that used to-day in Cairo in making *bouza*, no evidence of malting can be identified, either in the tomb scenes or on the tomb models and how far the practice (which is not essential) dates back is not known.

Statements have been made that the ancient Egyptians used bitter and other flavouring substances for their beer, much as hops are now employed, and that these included lupin¹; skirret¹ (*Sium sisarum*); the root of an Assyrian plant¹; rue^{2, 3}; safflower^{3, 4}; mandrake fruit⁴; bitter orange peel⁵ and resin,⁵ but the evidence (much of which is of very late date) is unsatisfactory and in some instances probably refers to the use of beer as a vehicle for medicine and not to the flavouring of beer as a beverage. One authority often quoted is the Roman agricultural writer Columella, who says⁶ '... the Egyptians made the sweetish taste of their Pelusian beer more palatable by adding to it pungent spices and lupine.' According to Arnold, however,⁷ 'This passage... must be interpreted differently. What he intends to say is that pungent or bitter substances were eaten with the beer of Pelusium, such as lupine, so as to stimulate the enjoyment, which was a custom likewise in vogue with the Romans who partook of such substances as appertisers.' With respect to the use of the mandrake fruit, both Gauthier⁸ and Dawson⁹ have shown that the ancient

¹ J. G. Wilkinson, *The Ancient Egyptians*, 1890, I, p. 54.

² H. Schulze-Besse, *Bier u. Bierbereitung bei den Völkern der Urzeit*, I, *Babylonien u. Ägypten*, Geleitwort.

³ E. Huber, *Bier u. Bierbereitung bei den Ägyptern*, in *Bier u. Bierbereitung bei den Völkern der Urzeit*, p. 43.

⁴ M. Philippe, *Die Braukunst der Ägypter im Lichte heurtiger Brautechnik*, in *Bier u. Bierbereitung bei den Völkern der Urzeit*, p. 55.

⁵ J. Grüss, *Tagezeitung für Brauerei*, xxvii (1929), pp. 277-8.

⁶ *De re rustica*, x, 114.

⁷ J. P. Arnold, *Origin and History of Beer*, p. 87.

⁸ H. Gauthier, *Le nom hieroglyphique de l'argile rouge d'Éléphantine*, in *Revue Egyptologique*, xi (1904), pp. 1-15.

⁹ W. R. Dawson, *The Substance called Didi by the Egyptians*, in *Journal of the Royal Asiatic Society*, 1927, pp. 497-503.

Egyptian word, thought at one time to mean mandrake, has been mistranslated and is the name of a mineral (red ochre) and not of a plant. The bitter orange peel and the resin thought to have been used were found on a tray of funerary offerings (Eleventh Dynasty) accompanying some bread which was possibly beer-bread, but their use in beer is very improbable. In modern Nubian *bouza* neither flavours nor bitters are employed, though the Abyssinians in Bruce's time added to their *bouza* the bitter leaves of a certain tree called *ghesh*.¹

Naturally none of the ancient beer has remained to the present day and therefore, it has not been possible to examine it, but dried residues from beer jars^{2, 3 4, 5} and also the dried and exhausted grain after 'mashing'⁵ (i.e. maceration in water) have been discovered and a number of specimens of the former, ranging in date from the predynastic period to the Eighteenth Dynasty, have been examined by Dr. J. Grüss, of Berlin,^{6, 7} who found them to consist of starch grains from the corn used (which was not barley, but a kind of wheat known as Emmer (the only wheat grown in Egypt until a late date); yeast cells; moulds; bacteria and small proportions of various impurities. The yeast was principally a variety of wild yeast, previously unknown, which Dr. Grüss named *Saccharomyces Winlocki* after Mr. H. E. Winlock, who supplied the material for examination. The Eighteenth Dynasty yeast was found to have cells approximating in size to the modern yeast and to be of a more uniform shape and freer from moulds and bacteria than the earlier yeast, from which Dr. Grüss concludes that the ancient Egyptian brewer had anticipated the modern brewer by making a pure, or almost pure, yeast culture.⁸ The evidence for this, however, derived as it is from the examination of a single specimen,

¹ J. Bruce, *op. cit.*, pp. 66, 335.

² W. M. Flinders Petrie, *Prehistoric Egypt*, p. 43.

³ H. E. Winlock, *Egyptian Expedition*, 1918-20, *Bull. Met. Mus. of Art*, New York, II (1920), p. 32.

⁴ C. M. Firth, *Arch. Survey of Nubia*, 1909-10, p. 17.

⁵ W. M. Flinders Petrie, *Gizeh and Rifeh*, p. 23.

⁶ J. Grüss, *Zeitung für Brauerei*, xxvi (1928), pp. 1123-4; xxvii (1929), pp. 275-8, 517, 679-82; xxviii (1930), pp. 98, 774-6.

⁷ H. E. Winlock, *The Tomb of Meryet-Amün at Thebes*, pp. 32-3.

⁸ J. Grüss, *op. cit.*, xxvii (1929), pp. 681-2.

seems inadequate to support such a wide conclusion, since the purity of the yeast in question may have been due to some natural cause, such as an accidental greater freedom of that particular beer from contamination during brewing.

It may be mentioned that yeast is a uni-cellular plant belonging to the fungus family and is abundantly distributed throughout the world, being found wild on many plants (particularly on ripe fruits) and in the air: there are many varieties, two of the principal useful ones being the cultivated beer yeast (*Saccharomyces cerevisiae*) and the wild yeast (*Saccharomyces ellipsoideus*) which occurs on grapes and brings about vinous fermentation: many other yeasts are also known, but as some of them produce a bitter flavour, an objectionable taste or a persistent turbidity in the fermented liquid, these are avoided in modern brewing. On account of the ubiquity of yeast, fermentation is a natural process and when solutions containing certain kinds of sugar are exposed to the air, after a short time they begin to ferment.

WINE

Wine usually denotes the fermented juice of fresh grapes, and this was the principal wine of the ancient Egyptians, though they had also other kinds, namely, palm wine; date wine; according to Pliny¹ a further kind made from the *myxa* fruit and at a late date pomegranate wine, all of which may now be considered.

Grape Wine

Wine, meaning grape wine, is frequently referred to in the ancient Egyptian records,^{2,3} the earliest reference known to the author being one of the Third Dynasty,⁴ though the wine-press hieroglyph was used in the First Dynasty,⁵ from which period wine jars are also known.

Wine is mentioned as being used for divine offering, for

¹ XIII, 10.

² J. H. Breasted, *op. cit.*, v (Index), p. 170.

³ A. Erman, *op. cit.*

⁴ J. H. Breasted, *op. cit.*, I, 173.

⁵ W. M. Flinders Petrie, *Social Life in Ancient Egypt*, pp. 102, 135.

evening offering, for feast offering, for mortuary offering, for oblation, as a beverage and as being received as tribute.

Vintage scenes are often depicted upon tomb walls, thus to take a few examples, in a Fifth Dynasty tomb at Saqqâra¹; in a Sixth Dynasty tomb at Saqqâra²; in a Twelfth Dynasty tomb at El-Barsha³; in several tombs of the same period at Beni Hasan⁴ and in a number of mortuary chapels of Eighteenth and Nineteenth Dynasty dates respectively in the Theban necropolis,^{5, 6} the gathering, treading or pressing of grapes, or all three of these operations, are shown.⁷

The preparation of wine is a comparatively simple matter, all that is necessary being to crush the grapes in order to free the juice, which is separated from the stalks, skins and stones and then allowed to ferment, which it does naturally, chiefly by means of the wild yeasts (principally *Saccharomyces ellipsoideus*) present on the skins of the grapes, but also to some extent by the action of certain enzymes (largely zymase) present in the juice. The fermentation consists in the conversion of the sugars present in the juice [these being glucose (dextrose) and fructose (levulose)] into alcohol and carbon dioxide.

According to the scenes on the tomb walls already referred to, the grapes were crushed by treading until no more juice could be extracted, after which the residue was placed in a cloth or bag, which was tightly twisted in order to squeeze out the remaining juice. The juice was then poured into large pottery jars, where it fermented, but there is nothing to show

¹ N. de G. Davies, *The Mastaba of Ptahbetep and Akhetbetep at Saqqarah*, I, Pl. XXIII.

² The tomb of Mereruka (Mera).

³ P. E. Newberry, *El Bersheh*, I, Pls. XXIV, XXVI, XXXI.

⁴ P. E. Newberry, *Beni Hasan*, I, Pl. XII; II, Pl. XVI.

⁵ N. de G. Davies, *The Tomb of Nakht at Thebes*, Pls. XXII, XXIII, XXVI; *The Tomb of Puyemrê at Thebes*, Pls. XII, XIII; *The Tomb of Two Officials of Tutmosis the Fourth*, Pl. XXX; *Five Theban Tombs*, Pl. XXXI; *Two Ramesside Tombs at Thebes*, Pls. XXX, XXXII, XXXIII; *The Tomb of Nefer-Hotep at Thebes*, I, Pl. XLVIII.

⁶ A. E. Weigall, *A Guide to the Antiquities of Upper Egypt*, 1913, pp. 115, 123, 139, 160, 178.

⁷ See also (a) H. F. Lutz, *op. cit.*; (b) P. Montet, *La culture de la vigne et vendanges*, *op. cit.*, pp. 265-73; (c) P. Montet, *La fabrication du vin dans les tombeaux antérieurs au nouvel empire*, in *Recueil de travaux*, XXXV (1913), pp. 117-24.

whether the juice from the treading was mixed with that from the squeezing, or whether the two lots were fermented separately. The latter, having been in contact with the stalks and skins for a longer period, would have been the more astringent and the more highly coloured of the two, as when fermentation had produced alcohol, this would have extracted astringent substances from the stalks and, if 'black' grapes were used, also considerable colouring matter from the skins.

The colour of wine depends upon the colour of the grapes and whether or not the skins are included in the fermentation. White grapes necessarily produce white wine and, as the juice of 'black' grapes is also usually colourless,¹ these, too, will produce white wine, if the skins are separated before fermentation, though if the skins are not removed a red wine is obtained.

No literary reference to the colour of the grapes grown anciently in Egypt can be traced, and Miss C. Ricci states² that even in the Graeco-Roman papyri the colour is not mentioned, but the grapes shown on several tomb walls of the New Empire at Thebes appear to be dark-coloured.³ Erman states that under the Old Empire the wine included white, red and black varieties⁴: Petrie mentions white wine⁵: Athenaeus refers to the Egyptian wine varying in colour and mentions both white and pale wine.⁶ It seems probable, therefore, that both light and dark grapes were used.

The amount of alcohol produced in wine by fermentation is limited by two factors, one being the quantity of sugar present in the grapes and the other being the fact that the yeast is killed (with the consequent gradual slowing down and final arrest of the fermentation) by the alcohol formed when the proportion reaches about 14 per cent,⁷ although there may still

¹ Some few kinds of 'black' grapes give a coloured juice.

² C. Ricci, *La Coltura della Vite e la fabbricazione del Vino nell' Egitto Greco-Romano*, 1924, p. 61.

³ N. de G. Davies, (a) *The Tomb of Nakht at Thebes*, Frontispiece, Pls. XXV, XXVI; (b) *Two Ramesside Tombs at Thebes*, Pl. XXXIII.

⁴ A. Erman, *Life in Ancient Egypt*, 1894, p. 196.

⁵ W. M. Flinders Petrie, *Social Life in Ancient Egypt*, p. 136.

⁶ *The Deipnosophists*, I, 33.

⁷ The excess of alcohol above about 14 per cent in certain modern wines is due to the addition of extra alcohol.

be fermentable sugar present and, if the grapes used are rich in sugar, the portion that escapes fermentation remains, imparting sweetness to the wine.

In ancient Egypt, on account of the slow method of pressing adopted and the high temperature at the end of the summer, when the vintage must have taken place, the fermentation would almost certainly have commenced before all the juice was extracted, but it principally occurred in the large jars to which the juice is shown as being transferred while the pressing is still going on. These jars must necessarily have been left open until the fermentation had almost ceased, otherwise they would have burst from the pressure of carbon dioxide generated; but when the fermentation was almost over the jars were stoppered with 'a wad of vine leaves' over which 'was moulded roughly with the fingers to a height of about 10 cm. a tenacious mixture of black earth and chopped straw,' as found by Winlock at the Christian Monastery of Epiphanius at Thebes,¹ or with 'a rush bung completely covered over with a clay or mud capsule that enveloped the whole of the mouth and neck of the jar' in the manner of those found by Carter in the tomb of Tut-ankhamûn,² or with such variant of the method as the local conditions and the importance of the wine demanded. Wine jars stoppered and sealed are represented in a number of tombs, for example, in one of the Twelfth Dynasty at Beni Hasan³ and in two of the Eighteenth Dynasty at Thebes, namely, in that of Nakht and in that of Nefer-Hotep.⁴ The closing of the jars as soon as possible was essential, since if the wine had been left exposed to the air, another kind of fermentation (the acetous fermentation) caused by a minute organism (*Mycoderma aceti*), always present in the air, would have taken place, which would have converted the alcohol into acetic acid and the wine would have become vinegar. The jars, however, were not all hermetically sealed at this stage, since in

¹ H. E. Winlock and W. E. Crum, *The Monastery of Epiphanius at Thebes*, I, p. 79.

² Howard Carter, *The Tomb of Tut-ankh-Amen*, III, p. 148; Pl. L.

³ P. E. Newberry, *Beni Hasan*, I, Pl. XII.

⁴ N. de G. Davies, (a) *The Tomb of Nakht at Thebes*, p. 70, Pl. XXVI; (b) *The Tomb of Nefer-Hotep at Thebes*, Pl. XLVIII.

some instances slow fermentation was still going on, in which case a small hole was made in the stopper, as shown in some of those from the Monastery of Epiphanius¹ and those from the tomb of Tut-ankhamûn² in order to provide a way of escape for the carbon dioxide being given off in small amount and, when the fermentation was finished, this hole was sometimes 'stopped with a wisp of straw'¹ and sometimes closed with clay and sealed.² At the Monastery of Epiphanius only about half the jars had been provided with this small vent.¹ Doubtless occasionally a jar would be finally sealed before fermentation had ceased, and in such a case the internal pressure might be sufficient to break the jar, as appears to have occurred with one of those from the tomb of Tut-ankhamûn, where the neck seems to have been ruptured and the contents to have flowed down the outside of the jar.

During the Graeco-Roman and Coptic periods wine jars were rendered impermeable by being treated inside with a thin coating of resin, which is always black, the colour probably being due to the charring of a non-black resin by the heat necessary to render it sufficiently liquid to flow as a thin layer over the inside of the jar. A deposit of similar black resin is often found at the apex of the jars that have been treated in this manner.³ Wine jars blackened inside were discovered at the Monastery of Epiphanius at Thebes by Winlock, who in describing them says, 'Like the Greek wine jars the inside was coated with a black resinous pitch . . .'¹ This practice was also known to the Romans, since Pliny⁴ refers to 'The pitch (i.e. blackened resin) . . . for preparing vessels for storing wine . . .' With reference to the wine jars from the tomb of Tut-ankhamûn, Carter states⁵ that 'In all probability the interior of the jars was smeared over with a thin coat of resinous material to counteract the porous nature of the pottery; the broken specimens show a distinct black coating on their inner

¹ H. E. Winlock and W. E. Crum, *op. cit.*, p. 79.

² Howard Carter, *op. cit.*, pp. 148-9.

³ Specimens of the black coating and the black material from the apex of wine jars of the Graeco-Roman period have been analysed and found to be resin in every case. See C. C. Edgar, *Zenon Papyri*, III, 197-8.

⁴ XIV, 25.

⁵ *Op. cit.*, pp. 148-9.

surface.' The author has examined twenty-two wine jars or parts of wine jars from this tomb,¹ of which twenty were broken, ten of them being much broken, thus making the examination a fairly easy matter. The outsides of the jars vary considerably in colour, some being entirely greenish-grey, some entirely red and some partly one colour and partly the other. The insides of the jars are chiefly light-red, though occasionally drab with a reddish tint, but in no instance is there any blackening of the nature of that on the Graeco-Roman wine jars, no resin at the apex and no continuous black coating of any sort, though in some cases there are black spots and small black patches that look very like fungus growths (which they probably are) but in most cases there is not any blackening at all.² The edges of the broken surfaces vary in colour from a drab with a slight reddish tint to light-red, mottled in every instance with innumerable white particles, which on testing proved to be calcium carbonate (carbonate of lime). There cannot be any doubt, therefore, that the clay used for these jars was calcarious (i.e. contained calcium carbonate), which explains both the greenish-grey and the red colours, the former being where the jars have been strongly heated and the latter where the heat has been less intense.³ No evidence of any slip could be found, either inside or outside the jars, and it must be assumed, therefore, that they were sufficiently watertight for the purpose required without either slip or resin coating.⁴ That they were not absolutely impermeable seems to be proved by the fact that those of the jars that are unbroken and still stoppered and sealed are empty.

In the Eighteenth Dynasty wine was being obtained from the eastern and western Delta⁵ and as tribute from Asia (Arvad,

¹ Five were of the long-necked Syrian type. Fourteen other jars from this tomb were not examined, since nine are still stoppered and sealed, and five, including two additional ones of the Syrian type, are in the Museum show case.

² One jar with a broken neck (No. 541) was rinsed with water inside and that it was entirely free from blackening was confirmed.

³ See p. 332.

⁴ One jar (No. 541) was filled with water and allowed to stand for forty-six hours; there was no leakage of water and the jar was not even damp on the outside.

⁵ Howard Carter, *The Tomb of Tut-ankh-Amen*, III, p. 147.

Zahi and Retenu)¹: in the Twenty-second and Twenty-sixth Dynasties respectively it was obtained from the oases of the western desert² and in the Twenty-sixth Dynasty from the western Delta.²

Herodotus strangely enough says that there were no vines in Egypt,³ though he mentions that the Egyptian priests drank wine⁴ and used it in the temple sacrifices⁵ and that wine was consumed at certain festivals,⁶ but since he records the importation of wine into Egypt from Greece and Phoenicia,⁷ he may have thought that all the wine used in the country was of foreign origin.

Diodorus refers to the vines of Egypt⁸ and to the drinking of wine.⁹

Strabo states¹⁰ that Libyan wine, which he says was mixed with sea water, was of poor quality, but that another Egyptian wine, the Mareotic, made in large quantity, was good; he also refers to wine from an oasis in the western desert¹¹ and to wine from the Fayûm province,¹² which latter he says was produced in abundance.

Pliny, in his enumeration of wines foreign to Italy, includes a kind termed Sebennys, made in Egypt, from three different varieties of grapes 'of the very highest quality,'¹³ namely, the Thasian grape, the 'smoky' grape and the 'pitchy' grape. The Thasian grape, probably so called because it had been introduced into Egypt from Thasos, is described¹⁴ as being 'remarkable for its sweetness and laxative qualities.' Pliny also mentions an Egyptian wine that he states produced miscarriage.¹⁴

Athenaeus quotes Hellanicus for the statement that the vine was first discovered in Egypt,¹⁵ and he quotes Dio as saying that the Egyptians were fond of wine and bibulous,¹⁵ and he himself calls them wine-bibbers¹⁵: he states,¹⁵ too, that 'The vine is as abundant in the Nile valley as its waters are copious, and the peculiar differences of the wines are many, varying

¹ J. H. Breasted, *op. cit.*, v (Index), p. 170.

² Breasted, *op. cit.*, iv, 734, 992.

³ II, 77.

⁴ II, 37.

⁵ II, 39.

⁶ II, 60.

⁷ III, 6.

⁸ I, 3.

⁹ I, 4.

¹⁰ xvii, 1, 14.

¹¹ xvii, 1, 42.

¹² xvii, 1, 35.

¹³ xiv, 9.

¹⁴ xiv, 22.

¹⁵ *Op. cit.*, I, 34.

with colour and taste': he also says¹ that the vine was abundant in the Mareotic region in the neighbourhood of Alexandria and that its grapes were 'very good to eat': he mentions several wines,¹ namely the Mareotan (excellent, white, pleasant, fragrant, easily assimilated, thin, does not go to the head, diuretic); the Taeniotic (better than the Mareotan, somewhat pale, has an oily quality, pleasant, aromatic, mildly astringent); the wine of Antylla, a city not far from Alexandria (surpassing all others), and the wine of the Thebaid and especially that from the city of the Copts ('so thin and assimilable, so easily digested, that it may be given even to fever patients without injury'). This same writer also states² that the Egyptians used boiled cabbage and also cabbage seeds as remedies against drunkenness and subsequent headache. With reference to the mixing of sea water and wine mentioned by Strabo³ as being practised with the Libyan wine, Athenaeus states⁴ that 'Wines which are more carefully treated with sea water do not cause headache; they loosen the bowels, excite the stomach, cause inflation, and assist digestion.' This practice of mixing sea water with wine is also mentioned by Pliny,⁵ according to whom, if done sparingly, it was thought to improve the flavour of the wine, though of one wine so treated he states⁵ that it 'is far from wholesome.'

There is no recorded instance known to the author of wine having been discovered in an Egyptian tomb, though wine jars and clay sealings from wine jars are very common. In some of the jars, however, there are the residues left after the evaporation of the liquid and three such residues have been analysed, two from the tomb of Tut-ankhamûn⁶ and one from the Monastery of St. Simeon near Aswan,⁷ the potassium carbonate and potassium tartrate found proving that the residues were those from wine.

¹ *Op. cit.*, I, 33.

² *Op. cit.*, I, 34.

³ XVII, I, 14.

⁴ *Op. cit.*, I, 32.

⁵ XIV, 9.

⁶ A. Lucas, in *The Tomb of Tut-ankh-Amen*, Howard Carter, III, Appendix II, p. 183. A second specimen was subsequently examined.

⁷ In this Monastery there may still be seen a complete installation for making wine. (U. Monneret de Villard, *Un Pressoio da Vino dell' Egitto Medioevale*, in *Reale Istituto Lombardo di Scienze e Lettere*, LIX, XI-XV, 1926; also *Descrizione Gen. del Monastero di S. Simeone presso Aswan*, in *Annales du Service*, XXVI (1926), p. 231.)

Palm Wine

A wine-producing palm is mentioned in the Pyramid Texts¹ and both Herodotus² and Diodorus³ state that palm wine was used in Egypt to wash out the abdominal cavity during the operation of mummification and Herodotus relates that Cambyzes sent a cask of palm wine to Ethiopia.⁴ Wilkinson says⁵ that palm wine was made in Egypt in his day and that it consisted of the sap of the date palm obtained by making an incision in the heart of the tree, immediately below the base of the upper branches and that, as taken directly from the tree, the liquid was not intoxicating, but acquired this property by fermentation when kept and that the wine resembled in flavour a very light new grape wine: he also states that a palm tapped in the manner described was rendered useless for fruit bearing and generally died. Mr. H. J. L. Beadnell, who knows the western oases well, having lived there, informed the author that a palm wine of the kind described by Wilkinson was still produced in Dakhla and that, if tapped in moderation, the tree was not killed. Oric Bates states⁶ that at the time he wrote an intoxicant was made in eastern Libya by fermenting the sap of the date palm. In Egypt, too, a similar wine is occasionally prepared, but always from a male tree that is not required, which dies as the result of the operation and is cut down. The fermentation of the sap is brought about by means of wild yeasts present on the tree and in the air.

Bruijning suggests⁷ that the palm wine used anciently in Egypt was obtained, not from the date palm, but from other species of palm, such as the Raphia palm, probably *Raphia monobuttorum*, which he thinks may have grown in Egypt at one time, though it is not now found in the country. It is true that the Raphia palm, which is an African tree, often found growing in forest swamps, does yield a wine and is used for wine making in certain parts of Africa and that it is some-

¹ F. F. Bruijning, *The Tree of the Herakleopolite Nome*, in *Ancient Egypt*, 1922, pp. 1-8.

² II, 86.

³ I, 7.

⁴ III, 20.

⁵ J. G. Wilkinson, *The Ancient Egyptians*, 1890, I, p. 55.

⁶ Oric Bates, *The Eastern Libyans*, p. 26.

⁷ F. F. Bruijning, *op. cit.*, pp. 3, 7.

times called the *Nakl-el-Faraoon* (Pharaoh's date palm),¹ but there is no evidence that it ever grew in Egypt and, as the palm wine made at the present time is from the date palm, there is no reason to think that it was otherwise anciently.

Date Wine

Date wine is occasionally mentioned in the ancient Egyptian records, for example in the Sixth Dynasty² and on two ostraca of the Nineteenth Dynasty in the Cairo Museum: it is also described by Pliny, who states³ that it was made 'throughout all the countries of the East,' which probably was meant to include Egypt, though Egypt is not specifically named. It was prepared by steeping a certain kind of date in water and pressing out the liquid, which was left to ferment, which it does naturally from the wild yeasts present on the dates. A similar beverage is described by Burckhardt⁴ as being made in Nubia by boiling ripe dates with water, straining the liquid and allowing it to ferment. Oric Bates states that in eastern Libya at the present day an intoxicant is made by fermenting dates.⁵ Until quite recently, a date wine, such as that described, was, and possibly still is, made in Egypt, but instead of being drunk as wine, the liquid was distilled and the resulting spirit consumed.

Myxa Wine

With respect to the Myxa wine stated by Pliny⁶ to have been made in Egypt, no other mention of it can be traced. The Myxa (*Cordia Myxa*), which is cultivated in gardens in Egypt, bears a mucilaginous fruit, which Theophrastus, who calls it 'the Egyptian plum,'⁷ describes without referring to any use having been made of it for wine making, although he states that it was made into cakes.

Pomegranate Wine

The only reference to pomegranate wine that can be found is in a late third century A.D. papyrus.⁸

¹ G. Schweinfurth, *The Heart of Africa*, I, p. 199.

² J. H. Breasted, *op. cit.*, I, 336.

³ XIII, 9; XIV, 19.

⁴ J. L. Burckhardt, *op. cit.*, p. 132.

⁵ Oric Bates, *op. cit.*, p. 26.

⁶ XIII, 10.

⁷ *Enquiry into Plants*, IV, 2, 10.

⁸ A. S. Hunt, *The Oxyrhynchus Papyri*, VIII, p. 241.

DISTILLED SPIRITS

Distillation is the process of converting a volatile liquid into vapour by heat and then recondensing it again by cooling, and distilled spirits are naturally-flavoured solutions of alcohol in water that have been made by the distillation of certain fermented liquids.

Although the ancient Egyptians made beer and wine, both of which contain alcohol, they were unacquainted with distillation and, therefore, did not know distilled spirits.

When and where the discovery of distillation took place there is no evidence to show, but the first mention of it that can be traced is by Aristotle in the fourth century B.C., who describes the formation of mist and rain¹ (which are caused by natural processes of evaporation and condensation) and who also says,² 'Salt water when it turns into vapour becomes sweet and the vapour does not form salt water when it condenses again. This I know by experiment. The same thing is true in every case of the kind: wine and all fluids that evaporate and condense back into a liquid state become water. They are all water modified by a certain admixture, the nature of which determines their flavour.' Evidently Aristotle, although apparently he had distilled wine and made dilute alcohol, did not recognize it as anything other than water 'modified by a certain admixture,' the nature of which determined its flavour. Theophrastus (fourth to third century B.C.) had some knowledge of a method of destructive distillation for obtaining wood tar, which he describes,³ and Pliny (first century A.D.) also knew of this,⁴ as well as of a primitive method of obtaining spirits of turpentine by means of distillation.⁵

Zosimos, who lived at the end of the third century A.D. or the beginning of the fourth, and who was a native of Panopolis in Upper Egypt 'and spent his early youth in Alexandria where he studied and wrote'⁶ and who is 'the most ancient alchemical author of whom we have genuine writings and whom we can

¹ *Meteorologica*, I, 9, 11.

² *Op. cit.*, II, 3.

³ *Enquiry into Plants*, IX, 3, 1-3.

⁴ XVI, 21-2.

⁵ XV, 7.

⁶ E. J. Holmyard, *Makers of Chemistry*, p. 35.

identify' ¹ describes and illustrates a variety of retorts and recipients, thus proving that distillation was well known in his time, but he makes no mention whatever of alcohol, and it is highly probable that this was not known until the Middle Ages, its use at first being medicinal and not as a beverage.

SUGAR

In connexion with beer and wine, the use of sugar in ancient Egypt may conveniently be dealt with, as it was from sugar that the alcohol, which imparted the stimulating and intoxicating properties to both these beverages was derived. In the case of beer, sugar, as already described, was produced during the preliminary processes of brewing from the starch present in the grain used, while with wine, the sugar existed ready formed in the grapes, palm juice, dates or other materials employed.

Although sugar is widely distributed in nature, being present as honey; in milk and in certain trees, plants, roots, flowers and fruits, it was only generally known anciently in the form of honey, sugar from the sugar cane being of comparatively late date and that from the beetroot being still more recent.

Cane Sugar

The sugar cane is a native of the Far East and seems to have been first cultivated in India and the sugar from it was just becoming known to the Roman world in Pliny's time though only as a medicine.² From this same period (first century A.D.) there is a record of sugar or 'honey from the reed called *sacchari*' as it is termed, having been shipped from India to the Somali coast.³ The bare facts of the existence of sugar cane and the extraction of sugar from it, however, seem to have been known in Greece several centuries earlier than the date mentioned, as Nearchus (fourth century B.C.) is quoted by Strabo ⁴ (first century B.C. to first century A.D.) for the statement that 'reeds yield honey, although there are no bees . . .'; he

¹ E. J. Holmyard, *Makers of Chemistry*, p. 35.

² XII, 17.

³ W. H. Schoff, *The Periplus of the Erythraean Sea*, pp. 27, 90, 285.

⁴ XV, 1, 20.

also says that there was 'a tree from the fruit of which honey is procured . . .', the identity of which, however, unfortunately is not recorded. Pliny states that Arabia as well as India produced sugar.

So far as can be ascertained there is no mention of sugar from the sugar cane in any ancient Egyptian document, not even in the late Greek papyri, and the only sources of sugar readily available were honey, and such fruits as dates and grapes, but it was honey that took the place in daily life of the modern sugar, the sugar cane, now so largely grown in the country being a comparatively modern introduction. In the thirteenth century Marco Polo states¹ that certain Egyptians, skilled in the matter, instructed the inhabitants of Un-guen (China) in a method of refining sugar by means of wood ashes.

Honey

Bee-keeping was one of the important minor industries in ancient Egypt and honey is frequently mentioned in the ancient records,^{2, 3} the earliest references to it that can be traced being of the Sixth Dynasty^{4 5}: in the Eighteenth Dynasty it is named among various mortuary offerings⁶ and in this same dynasty it was included in the tribute from both Zahi⁷ and Retenu⁸ in Asia and in the Nineteenth Dynasty it is mentioned as part of the rations of the king's messenger and standard bearer.⁹ In both the Edwin Smith Surgical Papyrus (seventeenth century B.C.)¹⁰ and in the Papyrus Ebers (about 1500 B.C.)¹¹ honey is mentioned as a medicine: in the Eighteenth Dynasty tomb of Rekhmara at Thebes jars of honey are depicted and named¹² and in the tomb of Pabasa at Thebes (seventh century

¹ Marco Polo, *Travels*, p. 316. (Everyman's Library.)

² J. H. Breasted, *op. cit.*, v (Index), p. 132.

³ A. Erman, *The Literature of the Ancient Egyptians*.

⁴ J. H. Breasted, *op. cit.*, I, 366.

⁵ Papyrus in the Cairo Museum, No. J. 15,000.

⁶ J. H. Breasted, *op. cit.*, II, 571.

⁷ II, 462.

⁸ II, 518.

⁹ III, 208.

¹⁰ J. H. Breasted, *The Edwin Smith Surgical Papyrus*, Index, p. 583.

¹¹ C. P. Bryan, *The Papyrus Ebers*.

¹² P. E. Newberry, *The Life of Rekhmara*, pp. 29-33, 35.

B.C.) a scene of bee-keeping is shown.¹ In the Ptolemaic period 'there were royal as well as private bee-farms.'²

Two small pottery jars of Eighteenth Dynasty date, each marked in hieratic 'honey of good quality,' examined by the author were practically empty, except for a trace of dried material adhering to the inside. In one case this was analysed, so far as was possible with the very small quantity available, with the result that the chemical tests were negative, the only indication of sugar being a slight smell suggestive of caramel (burnt sugar) when the material was treated with hot water, in which twenty-six per cent was soluble. Another specimen from the New Kingdom submitted by Dr. L. Keimer as honey was entirely insoluble in water and gave no reaction whatever for sugar. These negative results, however, do not necessarily mean that the specimens had not been honey at one time, but merely indicate that, if honey, they had become so changed that they no longer responded to the usual tests.

A material found in considerable amount in a large alabaster jar in the tomb of Tut-ankhamûn³ was black and resinous-looking, with the upper surface covered with the chitinous remains of a very large number of small beetles: there were signs that at one time the substance had been viscous and had run, and throughout the black mass there were innumerable small translucent light-brown crystals. The bulk of the substance could not be identified, but the crystals were sweet, soluble in water and gave all the chemical reactions for sugar, which they undoubtedly were. What the material had been originally it is impossible to say, but honey or a fruit juice, such as grape juice or date extract, is suggested. According to Pococke⁴ 'the Mahometans make a syrup of the juice of the grape by boiling it: . . . it is used instead of sugar and they bring it also to the table and dip their bread in it . . .', and it is possible, therefore, that the ancient Egyptians made a similar use of grape juice.

¹ A. Lansing, *The Egyptian Expedition, 1916-1919*, in *Bull. Met. Mus. of Art, New York*, II (1920), pp. 21-2.

² E. Bevan, *A History of Egypt under the Ptolemaic Dynasty*, p. 149.

³ A. Lucas, *Appendix II*, p. 183, in *The Tomb of Tut-ankh-Amen*, III, Howard Carter.

⁴ R. Pococke, *A Description of the East and some other Countries*, p. 58.

It is stated that the Egyptians sometimes preserved their dead in honey;¹ but, if so, this was very exceptional, and the body of Alexander the Great, which is quoted as an example,¹ if so embalmed, was presumably treated in Babylon, where he died, and not in Egypt, and it was the preserved body that was brought to Egypt.

¹ E. A. Wallis Budge, *The Mummy*, 2nd edition (1925), p. 208.

CHAPTER II

ANIMAL PRODUCTS

It has been found convenient to group together in the same chapter various products of the animal kingdom, namely, Bone ; Feathers ; Glue ; Gut ; Hair ; Horn ; Ivory ; Leather ; Mother of Pearl ; Ostrich Egg-shell ; Tortoise-shell and Marine and Fresh Water Shells, all of which may now separately be considered.

BONE

Bone was one of the most natural materials for primitive man to use, since it was generally plentiful and was easily splintered and pointed (in the case of certain fish bones it was already pointed) and so, without difficulty, it could be made into small boring implements, such as awls and needles : it was also suitable for carving.

Animal bones were used in ancient Egypt from neolithic times^{1, 2} through all the subsequent periods, being made into various small objects, principally amulets, armlets, arrow heads, awls, beads, bracelets, combs, finger rings, harpoon heads, needles and pins. Fish vertebrae were occasionally made into beads³ and pointed fish bones into needles.⁴

FEATHERS

In most countries the use of feathers is known from very early times and in Egypt, which is no exception, the custom

¹ G. Caton-Thompson, *The Neolithic Industry of the Northern Fayum Desert*, in *Journal, Royal Anthropol. Inst.*, LVI (1926), pp. 310, 312.

² H. Junker, *Merimde-Benisalâme*, 1929, p. 237 ; 1930, pp. 71-2.

³ G. A. Wainwright, *Balabish*, p. 21.

⁴ T. E. Peet and C. L. Woolley, *The City of Akhenaten*, I, p. 17.

can be traced back to the Badarian period.¹ The feathers employed were chiefly those of the ostrich, though black feathers not from the ostrich, but possibly from the crow or raven, have also been found in tombs^{2, 3} and in one instance pigeon feathers.⁴

Ostrich feathers were used largely for fans and as a head ornament, thus Piankhi (Twenty-third Dynasty) received the submission of 'all the chiefs who wore the feather'⁵ (probably ostrich feathers) and both gods and chariot horses are often depicted wearing ostrich feathers: in the Middle Kingdom Egyptian colony at Kerma in the Sudan ostrich feathers were used for making both fans and rugs.⁶ The purpose of the black feathers mentioned is not known, but the pigeon feathers referred to were employed to stuff a cushion.

Although the ostrich is not now found in Egypt, it was fairly common at one time in both the eastern and western deserts and in the Eighteenth Dynasty it evidently existed as far north as Heliopolis, since on the handle of a fan from the tomb of Tut-ankhamûn the king is shown shooting ostriches with a bow and arrow and an inscription states that the hunt took place in 'the eastern desert of Heliopolis.'⁷ On the other side of the fan the king has a bundle of ostrich feathers under his arm and the servants are carrying two dead ostriches.

The local ostrich, however, apparently was not plentiful enough to supply all the feathers required, as some were imported, thus on the wall connecting the two pylons of Horemhab at Karnak ostrich feathers are shown being brought from Punt⁸ and, on one of the walls of the temple of Beit el-Wâli in Nubia, Ramesses II is depicted receiving Nubian tribute, which includes ostrich feathers.⁹

¹ G. Brunton and G. Caton-Thompson, *The Badarian Civilisation*, pp. 28, 38.

² G. A. Wainwright, *op. cit.*, p. 12.

³ C. M. Firth, *Arch. Survey of Nubia, Report for 1908-1909*, p. 58.

⁴ J. E. Quibell, *The Tomb of Yuua and Thuia*, *Cat. Gén. du Musée du Caire*, p. 52.

⁵ J. H. Breasted, *op. cit.*, IV, 873.

⁶ G. A. Reisner, *Excavations at Kerma*, IV-V, pp. 300-1, 315.

⁷ Howard Carter, *The Tomb of Tut-ankh-Amen*, II, p. 46.

⁸ J. H. Breasted, *op. cit.*, III, 37.

⁹ III, 475.

In several Eighteenth Dynasty tombs at Thebes ostrich feathers are pictured.^{1, 2, 3, 4}

GLUE

Glue was well known in ancient Egypt and was used for many different purposes, namely, (a) as an adhesive to fasten wood together and to fix ebony and ivory veneer and inlay in place ; (b) for mixing with whiting (chalk) to make both plaster and 'stopping' ; (c) probably as an adhesive to fasten coarse woven fabric to wood and to plaster and to fasten gold foil to plaster ; (d) probably as a sizing material for stone and plaster surfaces before painting and (e) possibly as an adhesive for pigments. These various uses may now be considered.

At what date and for what purpose glue was first employed is uncertain, but probably not originally as an adhesive for wood, since in the tomb of Hetepheres (Fourth Dynasty) the wood was fastened together by means of mortise and tenon joints and strips of hide,⁵ the latter of which suggest that glue was not used, though, as practically all the wood had decayed and disappeared, this could neither be proved nor disproved. Several specimens of plaster from this tomb, however, analysed by the author, consisted of whiting (chalk) with a mixture of nitrogenous organic matter that might have been glue, since, so far as could be determined from the small amount of material available for analysis, there was no other adhesive present and some adhesive is essential, whiting possessing no natural coherence whatever.

Plaster of this nature (i.e. whiting and glue which is termed 'gesso' by Egyptologists) has been identified by the author from the Third Dynasty, where it was used for fastening the small blue faience tiles to the walls in the great tomb of Zoser

¹ J. G. Wilkinson, *The Ancient Egyptians*, 1890, II, p. 54.

² A. E. P. Weigall, *A Guide to the Antiquities of Upper Egypt*, 1913, p. 126.

³ Nina de G. Davies and Norman de G. Davies, *The Tombs of Menkheperresonb Amenmose and Another*, Pl. IX.

⁴ N. de G. Davies, *The Tomb of Puyemrê at Thebes*, I, pp. 87, 103.

⁵ G. A. Reisner, *Bull. Mus. of Fine Arts, Boston*, xxv (1927), Supplement ; xxvi (1928), No. 157 ; xxx (1932), No. 180.

at Saqqâra, and also from the Fifth Dynasty, where a carved limestone bust was covered with a painted layer of this plaster : it was employed on a large scale in the Eighteenth Dynasty and onwards for applying to wood as a ground for painting and gilding, being often worked with designs in low relief before being gilt, and at a later date it was extensively used for covering the cartonnage mummy masks and coffins made from old papyrus documents. Where this plaster was on wood, there was sometimes a layer of coarse woven fabric (canvas) between the two and, not only was the canvas probably treated with glue to make it adhere to the wood on one side and to the plaster on the other, but in those instances in which the gold was thick (i.e. foil) this was probably also fastened on with glue, though whether glue was used when the gold was only thin leaf has not been determined.¹

A specimen of glue of early Eighteenth Dynasty date was found by Howard Carter in a rock chamber over the mortuary temple of Hatshepsût at El-Deir el-Bahari. This, which was examined by the author, was in the form of a rectangular piece 13 cm. long with a square section of about 2 cm. each way, that had manifestly been cast and, except that it had dried and shrunk, it could not be distinguished from modern glue, to all of the usual tests for which it responded.²

The use of glue is probably shown in a scene on a tomb wall of the Eighteenth Dynasty at Thebes,³ and glue was present on many of the objects from the tomb of Tut-ankhamûn, where it was employed to fasten wood together and to fix ebony and ivory veneer and inlay in place.⁴ A number of specimens of 'stopping' used to fill holes and to cover up imperfections in wood from this tomb were found to consist of a mixture of whiting and glue (i.e. gesso) coloured (in one case with yellow ochre) to match the colour of the wood.⁴ The possible use of glue as a sizing material for painting-grounds and as an adhesive for pigments will be discussed when dealing with painting.⁵

¹ See p. 189.

² A. Lucas, *Appendix II*, pp. 166-7, in *The Tomb of Tut-ankh-Amen*, II, Howard Carter.

³ P. E. Newberry, *The Life of Rekhmara*, Pl. XVII.

⁴ A. Lucas, *op. cit.*, pp. 167, 186.

⁵ See pp. 293-4.

GUT

A nitrogenous organic material, which has all the appearance of gut, and which was almost certainly made like modern gut from the intestines of animals, was employed in ancient Egypt both for the strings of certain musical instruments,¹ thus antedating the present day violin strings, and for bow strings, a number of which latter were found in the tomb of Tut-ankhamûn,² though at least one example of a linen bow string was also found.

HAIR

Human nature, being fundamentally the same everywhere and at all periods, it is not surprising to find that the women of ancient Egypt, even as early as the First Dynasty at least, used artificial locks of human hair to supplement their own when these had become scanty by reason of old age, or because fashion required it.^{3, 4, 5, 6, 7} Human hair, too, was employed for making wigs, though these were also sometimes made of vegetable fibre, but there is no evidence of horsehair or wool having been employed for this purpose despite the statements in the literature to this effect.⁸ The author has made a microscopical examination of the fibre of all the wigs in the Cairo Museum (fifteen altogether), the results of the examination of fourteen of which have been published.⁸

Seven of these are large ceremonial wigs of the priests of the Twenty-first Dynasty; they are covered with a mass of small corkscrew curls and have long narrow plaits hanging down

¹ Le Baillif, in *Catalogue des antiquités*, J. Passalacqua, p. 244.

² Howard Carter, *The Tomb of Tut-ankh-Amen*, III, p. 138. The material has been examined by the author and consists of nitrogenous organic matter.

³ G. Elliot Smith, *The Royal Mummies*, in *Cat. Gén. du Musée du Caire*, pp. 13, 14, 19, 20, 96, 105.

⁴ W. M. Flinders Petrie, *Abydos*, I, p. 5; Pl. IV (7).

⁵ W. M. Flinders Petrie, *Objects of Daily Use*, p. 5; Pl. IV.

⁶ C. M. Firth, *Arch. Survey of Nubia, Report for 1910-1911*, p. 169; Pl. II (c).

⁷ H. E. Winlock, *The Tomb of Queen Meryet-Amûn at Thebes*, pp. 9, 34.

⁸ For references see A. Lucas, *Ancient Egyptian Wigs*, in *Annales du Service*, xxx (1930), pp. 190-6.

behind. Although they have been described as consisting of horsehair,¹ they are all of human hair of a brown or dark brown colour when cleaned, though appearing black before cleaning, and are stuffed (evidently for the sake of economy) with fibres from the reddish-brown fabric-like material that surrounds the base of the branches of the date palm.

A further wig, described as from the same source as the previous seven, is much smaller and consists of small light brown curls without any plaits and without stuffing. This, too, is human hair. Another mass of hair (undated), probably at one time a wig, is very similar, though darker in colour and is also human hair.

Two other large wigs (undated) are very similar to the seven already mentioned, but without stuffing and consist of dark brown human hair.

The wig of Queen Isimkheb (Twenty-first Dynasty), which has been described¹ as 'hair mixed with the wool of a black sheep' is of very large size and is covered with small curls and has long narrow plaits behind, but no stuffing: it consists entirely of human hair, mostly of a dark brown colour.

Yuya's ceremonial wig (Eighteenth Dynasty) which has been described as 'woollen,'¹ is similar to that of Queen Isimkheb and consists entirely of human hair of a very dark brown colour.

Two further wigs of small corkscrew curls on a plaited base, both probably of Roman date, consist of vegetable fibre, one being certainly date palm fibre and the other probably grass.

On all the hair wigs without exception and on one of the fibre wigs there is beeswax, some of which was removed by means of a solvent and identified by its properties, particularly by the melting point. The present drab colour of many of the curls and plaits is due to dust and dirt that have adhered to the wax. As beeswax would be such an eminently suitable material to ensure the permanency of the curls and plaits there can be little doubt that it was for this purpose that it was employed and that its presence is not to be explained by any anointing, which would only be possible with a liquid oil, or

¹ For references, see A. Lucas, *Ancient Egyptian Wigs*, in *Annales du Service*, xxx (1930), pp. 190-6.

a solid fat liquefied by heat before use, or one that became liquid at the temperature of the human body, or of the room where the wig was being worn. The melting point of beeswax, which is slightly more than 60° C. (140° F.), is much too high for it to have melted and flowed over the wig had it been applied in the solid form and, therefore, it is practically certain that it must have been warmed and rubbed into the hair.

Small plaited locks of hair were sometimes treasured in ancient Egypt, as is often done to-day, and such a lock was found in the tomb of Tut-ankhamûn,¹ the hair being that of Queen Tyi, who was the grandmother of Tut-ankhamûn's wife and from whom Tut-ankhamûn himself was probably descended.

Brunton found two lots of human hair in tombs of Seventh to Eight Dynasty date, one of which was in the form of a small pad that had been used to apply a red powder, possibly to the face, and the other was associated with eye and face paint.²

Hair was occasionally employed for threading beads, an example of this being known for a bracelet of First Dynasty date from Abydos.³ Another bracelet or other ornament of the same place and date was in part composed of hair.⁴ The nature of the hair in these two cases has not been determined. Animal hair, however, was sometimes used for this purpose, and beads of the Badarian period have been found strung on animal hair, the particular kind of which was not determined.⁵ Various objects, too, were made of hair, such as the four from the tomb of Tut-ankhamûn, which the finder calls fly-whisks.⁶ These consist of bunches of long hair fixed in gilt wooden handles having the form of animals' heads, and they are possibly the objects so often shown hanging down at the sides of chariot horses and which are depicted on several pieces of the gold decoration belonging to the harness from this tomb. As pointed out to the author by Dr. H. H. Nelson, these objects must

¹ Howard Carter, *The Tomb of Tut-ankh-Amen*, III, p. 87.

² G. Brunton, *Gau and Badari I*, pp. 36, 55.

³ W. M. Flinders Petrie, *The Royal Tombs of the Earliest Dynasties*, II, p. 19.

⁴ A portion only exists and is in the Cairo Museum, but no published reference can be traced.

⁵ G. Brunton and G. Caton-Thompson, *The Badarian Civilisation*, p. 57.

⁶ Howard Carter, *The Tomb of Tut-ankh-Amen*, II, p. 224; Pl. XLIII (c).

have been bundles of fibres, as they are sometimes given a wavy appearance to indicate that they are streaming with the wind. This hair is in so disintegrated a condition that although it has been examined microscopically in the usual manner it is impossible to identify it with certainty, but it is probably either horsehair or donkey hair. Fly-whisks of giraffe-tail hair, possibly mixed with a little goat hair, were found by Reisner in the graves of the Middle Kingdom Egyptian colony at Kerma in the Sudan,¹ where there were also a number of armlets of giraffe-tail hair.¹ At Balabish Wainwright found a net bag of giraffe-tail or elephant-tail hair² and in Nubia Firth discovered an armlet of elephant-tail hair.³ Hair cords and a piece of very coarse hair cloth of the seventh century A.D. were found by Winlock at Thebes,⁴ but the nature of the hair is not stated.

HORN

Although horn was used in ancient Egypt from the earliest periods, comparatively few objects made from this material have been found in graves. From predynastic times, armlets,^{5, 6} combs,⁵ harpoon heads,⁶ tags,⁶ vases or cups⁵ and a carved horn adapted for use as a receptacle⁷ are known and from later periods, miscellaneous objects, including horns used as receptacles and horn handles for weapons.

IVORY

Ivory, both that from the elephant and that from the hippopotamus, was extensively employed in ancient Egypt from neolithic times⁸ onwards, largely because it was dense and

¹ G. A. Reisner, *Excavations at Kerma*, IV-V, pp. 313-15.

² G. A. Wainwright, *Balabish*, pp. 12, 32, 46.

³ C. M. Firth, *Arch. Survey of Nubia, Report for 1910-1911*, p. 84.

⁴ H. E. Winlock and W. E. Crum, *The Monastery of Epiphanius at Thebes*, pp. 71-2.

⁵ W. M. Flinders Petrie, *Prehistoric Egypt*, pp. 30, 31, 40, 48.

⁶ W. M. Flinders Petrie and J. E. Quibell, *Naqada and Ballas*, pp. 46-7.

⁷ G. Brunton and G. Caton-Thompson, *op. cit.*, p. 60.

⁸ H. Junker, *Merimde-Benisalâme*, 1929, p. 237; 1930, pp. 71-2.

fine-grained and well adapted for carving, in which work the ancient Egyptians were very skilled. This considerable use of ivory at an early date, although it must mean that the elephant was well known, does not necessarily imply that it was then wild in Egypt, which was probably not so, but merely that being plentiful in the country immediately to the south of Egypt (the Sudan), a supply of ivory would be easily accessible. The hippopotamus, on the other hand, was still abundant in Egypt, even as late as several hundred years ago. According to the ancient records ivory was obtained from Negro Lands (Sixth Dynasty)¹; Punt (Eighteenth Dynasty)²; God's Land (Eighteenth Dynasty)³; Genebteyew (Eighteenth Dynasty)⁴; Kush (Eighteenth Dynasty)⁵ and the South Countries (Eighteenth Dynasty)⁶ all of which were situated in Africa to the south of Egypt, but in addition also from Tehenu (Eighteenth Dynasty),⁷ which, too, was in Africa, though to the west, and from Retenu (Eighteenth Dynasty)⁸ and Isy (Eighteenth Dynasty),⁹ both of which were in Asia. The ivory objects found in the tombs include armlets, arrow tips, boxes, bracelets, combs, cylinders (carved), dishes (shallow), figures (human and animal), hair pins, handles for knives, daggers, fans and whips, harpoon heads, inlay, legs for articles of furniture, mace heads, vases, veneer and wands.

Carved ivory objects were sometimes artificially stained (not painted), generally red, but occasionally very dark brown or black or very rarely green, the nature of which colours, however, it has not been possible to determine.

LEATHER

In a country such as Egypt where cattle, sheep and goats were domesticated as early as the neolithic period and where there were many wild animals that were hunted at a still earlier date, namely, during paleolithic times, it is only natural that animal skins should have been made use of as clothing, and,

¹ J. H. Breasted, *op. cit.*, I, 336.

³ II, 265.

⁶ II, 652.

⁹ II, 493, 521.

⁴ II, 474.

⁷ II, 321.

² II, 263, 265, 272, 486.

⁵ II, 494, 502, 514.

⁸ II, 447, 509, 525.

although they have not been found from either the paleolithic or the neolithic period, they have been frequently discovered in both Badarian¹ and predynastic graves,² having been used both as clothing for the living and wrappings for the dead. From raw hide to skin treated sufficiently to render it pliable and thence to fully tanned leather are steps that the Egyptians took at a very early date, and articles of leather are common in both Badarian³ and predynastic tombs.⁴ Leather working is depicted in one tomb of the Eighteenth Dynasty⁵ and in another of the Twenty-sixth Dynasty,⁶ both at Thebes.

Leather was used for bags; braces (which were probably a priestly insignia in the Twenty-first and Twenty-second Dynasties); cushion covers; chariot flooring and tyres; dagger sheaths; harness; quivers; ropes; sandals; dog collars; seats of chairs and stools; tents; for writing upon and for various other purposes. The largest piece of leather work that has survived is the funeral tent of Queen Isimkheb (Twenty-first Dynasty), now in the Cairo Museum. Leather applique work in colours and leather cut into fine network are known. Leather was frequently dyed, the colours being red, yellow or green. At what period leather dyeing was first practised is uncertain, but the red colour, which appears to have been used before either of the other two, is known from the Eleventh Dynasty⁷ and also from certain 'pan' graves.⁸ The nature of the dyes has not been determined, but the red was possibly kermes and the yellow, pomegranate rind.

Kermes, which consists of the red dried bodies of a female insect (*Coccus ilicis*), is one of the oldest dye substances known, and, as it is stated to be useless without a mordant, but gives a red colour with alum, it was probably used with an alum mordant. The kermes insect feeds on a particular kind of

¹ G. Brunton and G. Caton-Thompson, *The Badarian Civilisation*, pp. 19, 40.

² W. M. Flinders Petrie, *Prehistoric Egypt*, p. 47.

³ G. Brunton and G. Caton-Thompson, *The Badarian Civilisation*, p. 41.

⁴ W. M. Flinders Petrie, *Prehistoric Egypt*, pp. 34, 43, 47.

⁵ P. E. Newberry, *The Life of Rekhmara*, Pls. XVII, XVIII.

⁶ The tomb of Aba (No. 36) in the Asasif.

⁷ An object of red leather described as a 'tag from wrists' of Eleventh Dynasty date from El Deir el-Bahari is in the Cairo Museum (No. J. 51874).

⁸ Information kindly supplied by Mr. Guy Brunton.

oak tree that grows in south-eastern Europe and in north Africa.

Pomegranate rind is sometimes employed in Egypt to-day for dyeing leather a yellow colour and possibly, therefore, it was used anciently, though its use seems unlikely before the Eighteenth Dynasty, the earliest date at which the tree, which is not a native of Egypt but of western Asia, is known in the country.¹

Specimens of ancient leather, varying in date from the Eighteenth Dynasty to about the Twenty-third Dynasty, have kindly been examined for the author by Dr. R. H. Pickard, F.R.S.,² and in several instances goat skin was identified, one example being from the seat of a stool from the tomb of Tut-ankhamûn³ and another being sandals from about the Twenty-second or Twenty-third Dynasty, whereas sandals from the tomb of Tut-ankhamûn were possibly calf skin.³

The nature of the tanning materials used by the ancient Egyptians has never thoroughly been investigated, but Theophrastus (fourth to third century B.C.), after describing the acacia (probably *Acacia arabica*) as an Egyptian tree, goes on to say that the fruit is a pod, which 'the natives . . . use for tanning hides instead of gall,'⁴ and Pliny (first century A.D.), probably copying from Theophrastus, states that the pods of an Egyptian thorn tree (probably *Acacia arabica*) were 'employed for the same purpose as galls in the preparation of leather.'⁵ These pods contain about 30 per cent of tannin and are used in the Sudan at the present day for tanning purposes, and, therefore, from theoretical considerations alone it is not at all unlikely that they were used for a similar purpose in ancient Egypt, which has recently been proved by Bravo,⁶ who has examined the material (skins, tanned leather, tools and tanning

¹ V. Loret, *La Flore pharaonique*, 2nd edition (1892), pp. 76-7.

² At that time Director of The British Leather Manufacturers' Research Association.

³ A. Lucas, Appendix II, p. 176, in *The Tomb of Tut-ankh-Amen*, II, Howard Carter.

⁴ *Enquiry into Plants*, IV, 2, 1; IV, 2, 8.

⁵ XIII, 9.

⁶ G. A. Bravo, *Leather in Ancient Egypt*, in *Journal of the International Society of Leather Trades Chemists*, XVII (1933), pp. 436-7 (*Boll. Uff. R. Staz. Sperim. per l'Ind. delle Pelli*, etc., 1933, p. 75).

material) from the remains of a tannery of predynastic date found at Gebelein in Upper Egypt and now in the Turin Museum. The skins were goat skins, the leather was undoubtedly tanned and the tanning agent consisted of pods of the acacia (*Acacia arabica*) still containing 31·6 per cent of 'tans.' In the case of the specimens of leather, already mentioned, examined by Dr. Pickard, although special search was made for both vegetable and mineral tanning substances, the results were negative.

MOTHER OF PEARL

Mother of pearl is the nacreous material lining the shells of the pearl oyster and pearl mussel and is of the same composition as pearl, namely, essentially calcium carbonate.

Mother of pearl seems to have been very little used in ancient Egypt north of Aswan, and, with the exception of the well known large shells, many of which bear the cartouche of Sesostris I (Twelfth Dynasty),¹ only a few other examples of its use can be traced, these including small oblong strips of 'pan-grave' date for threading as bracelets²; a scarab of Eighteenth Dynasty date³; a pair of earrings of the Roman period⁴ and an amulet on a Coptic necklace.⁵ It was employed, however, to a greater extent in Nubia, where it has been found in graves from archaic times onwards, the objects made from it being chiefly bracelets, button-like objects, pendants and rings.

As mother of pearl may be obtained from the Red Sea, this was undoubtedly the source of the ancient supply.

OSTRICH EGG-SHELL

There is abundant evidence, both textual and monumental, to show that at one time the ostrich was fairly plentiful in

¹ H. E. Winlock, *Pearl Shells of Se'n-Wosret I*, in *Studies presented to F. Ll. Griffith*, pp. 388-92.

² G. A. Wainwright, *Balabish*, p. 20; Pl. III, 13; W. M. Flinders Petrie, *Diospolis Parva*, p. 45.

³ P. E. Newberry, *Scarab-shaped Seals*, in *Cat. Gén. du Musée du Caire*, p. 368.

⁴ W. M. Flinders Petrie, *Objects of Daily Use*, p. 14; Pl. X (250-1).

⁵ In the Cairo Museum, No. J. 57141.

both the eastern and western deserts of Egypt, though it is now no longer found in the country.

Among the earliest objects of any kind from ancient Egypt are ostrich egg-shells (often broken) and small disk beads and pendants made from them. These beads are very common in the earlier periods (neolithic,¹ ² Badarian³ and predynastic⁴), though they occur at all times, except during the Eighteenth Dynasty, at the beginning of which they ceased abruptly, but they began to come in again during the Nineteenth Dynasty and were still made in the Twenty-second Dynasty.⁵

TORTOISE-SHELL

Modern tortoise-shell consists of the epidermic plates of a small species of sea turtle, but in ancient times probably the plates of more than one kind of turtle and possibly also of the land tortoise were used. A sea turtle is found both on the Mediterranean and Red Sea coasts of Egypt and a small land tortoise in Sinai and possibly also in the western desert and the remains of very large land tortoises of Eocene times have been found in the Fayûm province.

Tortoise-shell was valued in Egypt from a very early date and a large number of the objects of this material have been found in graves, particularly in Nubia, among which may be mentioned part of a ring; bracelets; a dish; a comb; a sounding board of a harp,⁶ as also several complete shells.^{7, 8} The objects range in date from predynastic,⁹ and possibly even Badarian,¹⁰ times onwards.

¹ G. Caton-Thompson, *The Neolithic Industry of the Northern Fayum Desert*, in *Journal Royal Anthropol. Inst.*, LVI (1926), p. 312.

² G. Caton-Thompson and E. W. Gardner, *The Prehistoric Geography of Kharga Oasis*, in *The Geographical Journal*, LXXX (1932), p. 371.

³ G. Brunton and G. Caton-Thompson, *The Badarian Civilisation*, pp. 3, 28.

⁴ W. M. Flinders Petrie, *Prehistoric Egypt*, p. 43.

⁵ G. A. Wainwright, *Balabish*, p. 22.

⁶ British Museum, *A Guide to the Third and Fourth Egyptian Rooms*, 1904, p. 173.

⁷ Carnarvon and Carter, *Five Years' Explorations at Thebes*, p. 76.

⁸ Gaillard and Daressy, *La faune momifiée de l'antique Égypte*, in *Cat. Gén. du Musée du Caire*, p. 69.

⁹ W. M. Flinders Petrie, *op. cit.*, p. 31.

¹⁰ G. Brunton and G. Caton-Thompson, *op. cit.*, p. 30.

MARINE AND FRESH WATER SHELLS

Shells are very common in ancient Egyptian graves, especially in those of early date, and their use goes back to neolithic times. The smaller kinds were used chiefly as amulets, pendants, and strung together to form necklaces and girdles, while the larger shells were employed as receptacles for eye paints and other pigments. The greater proportion of these shells were from the Red Sea, though shells from the Mediterranean, fresh water shells from the Nile and land shells¹ were also used.¹⁻⁹

One kind of shell sometimes employed was dentalium, a marine mollusc having a white, narrow, tubular shell that occurs on the shores of the Red Sea,¹⁰ which were occasionally threaded and used as beads. Although this has been reported from both Badarian¹¹ and predynastic times,¹¹ the finder now agrees that the material was wrongly identified by the expert consulted and that it is organ coral and not dentalium. A small lot of dentalium shells, however, of unknown date, marked 'Mitraheneh' are in the store of the Cairo Museum. Dentalium has been found in mesolithic burials in Palestine.¹²

¹ W. M. Flinders Petrie, *Six Temples at Thebes*, pp. 30-1.

² G. Caton-Thompson, *op. cit.*, p. 313.

³ G. Brunton and G. Caton-Thompson, *op. cit.*, p. 38.

⁴ G. Brunton, *Qau and Badari I*, p. 71.

⁵ G. A. Wainwright, *op. cit.*, pp. 17-19.

⁶ G. A. Reisner, *Excavations at Kerma*, IV-V, p. 319.

⁷ D. Randall-MacIver and A. C. Mace, *El Amrah and Abydos*, p. 49.

⁸ Lortet and Gaillard, *La faune momifiée de l'ancienne Égypte*, I, pp. 191-8 ; II, pp. 105-22, 307-25.

⁹ Gaillard and Daressy, *op. cit.*, pp. 75-84.

¹⁰ T. Barron and W. F. Hume, *Top. and Geol. of the Eastern Desert of Egypt*, pp. 127, 137.

¹¹ G. Brunton and G. Caton-Thompson, *op. cit.*, pp. 38, 56.

¹² Dorothy A. E. Garrod, in *Man*, xxxi (1931), 159.

CHAPTER III

BUILDING MATERIALS

The nature of the building materials employed in any country depends upon many factors, the principal of which are the climate, the degree of civilization of the people and the kind of materials available.

Diodorus (first century A.D.) states¹ that 'They say the Egyptians in ancient times . . . made their houses of reeds, of which there are some marks amongst the shepherds at this day, who care for no other houses, but such like, which they say serves their turn well enough.' In Egypt, therefore, one may look back in imagination to a period when primitive shelters of dried reeds² were erected as a protection from the sun and wind, and one can also imagine the next stage of development when the reeds were plastered with clay in order to keep out the heat and cold more effectually. In two localities the remains of what were probably structures of this nature of predynastic date (in one case reeds plastered with clay³ and in the other case twigs plastered with clay⁴) have been found.

At a later period the need of something more substantial than clay-plastered reeds or twigs was manifestly felt. The available suitable materials with which to make a more solid habitation were clay and stone, and, as suggested, clay had probably already been used to fortify the original reed shelters and, if so, its properties would have been familiar, whereas the knowledge and tools necessary for quarrying and dressing stone in quantity

¹ I, 4.

² At the present day temporary shelters of maize stalks are common in the fields, maize, however, being a modern importation into Egypt.

³ G. Brunton and G. Caton-Thompson, *The Badarian Civilisation*, pp. 82-3.

⁴ J. Garstang, *Mabâsna and Bêt Khallaf*, pp. 6-7.

did not exist, and, therefore, clay, the known and more easily worked material, was chosen and was made into bricks, which were dried in the sun. The use of stone followed later when civilization had advanced sufficiently to provide metal (copper) tools.

Brick and stone will now be considered, as also the auxiliary materials required for building, namely, mortar, plaster and wood.

BRICK

Brick making is one of the oldest of the arts and was known to most of the nations of antiquity, but in few places has it been practised more than in Egypt, where sun-dried bricks still are, as they always have been, the characteristic building material of the country, and in the villages and smaller towns of Egypt the houses to-day are built of bricks similar to those that were used about 6000 years ago.

The oldest bricks that have been found in Egypt are of pre-dynastic date, examples being at Naqada in Upper Egypt¹ and those lining two royal tombs at Abydos,² also in Upper Egypt. In tombs of First and Second Dynasty date at both Saqqâra and Abydos bricks are very common and at Abydos, too, there is a ruined brick fort of the Second Dynasty the walls of which are still about 35 feet high.³

The bricks are made of Nile alluvium, or Nile mud as it is termed, of which all the cultivated land of Egypt consists and which is essentially a mixture of clay and sand, containing small amounts of impurities. The relative proportions of the two principal ingredients vary in different localities, and it is on the clay that the plastic and cohesive properties of the mud depend. When the percentage of clay is high, the mud is sufficiently tenacious to cohere without any extraneous binding material, though if the mixture is too rich in clay it is not satisfactory and bricks made from it, not only dry slowly, but during drying, shrink, crack and lose their shape. In order to

¹ W. M. Flinders Petrie and J. E. Quibell, *Naqada and Ballas*, p. 54.

² W. M. Flinders Petrie, *A History of Egypt*, I (1923), pp. 4-5.

³ W. M. Flinders Petrie *Social Life in Ancient Egypt*, p. 151.

prevent this, such alluvium is mixed with sand, chopped straw or other material. Chopped straw is also sometimes added, either as a binder when the proportion of clay is low, or simply to prevent the bricks from sticking to the ground during drying. The Egyptian practice of using straw in making bricks is mentioned in the Bible.¹ Chopped straw, however, and also animal (donkey) dung, which latter is occasionally employed, not only act as mechanical binders, but probably also increase both the strength and plasticity of the clay, especially if well mixed with it and allowed to remain some time before use.²

The modern sun-dried bricks are made in wooden moulds and these moulds, as also the process in use, are practically identical with those employed anciently, as is shown by a mould of Twelfth Dynasty date found at Kahun³; by miniature moulds for funerary purposes, which have also been discovered,⁴ and by a tomb-painting of the Eighteenth Dynasty in the Theban necropolis.⁵

Since clay is plentiful and widely distributed in Egypt, and since sun-dried bricks do not require highly skilled labour, either for making or using, the houses constructed with them are cheap; they are also warm in winter and cool in summer and, although they would not stand the wet climate of Europe, they are very suitable for Egypt, where rain, except in the extreme north, is rare.

Old Egyptian bricks differ considerably in size, some being much the same dimensions as modern bricks, while others are very large, for example, two in the Cairo Museum each measure approximately $38 \times 21 \times 12$ inches.

With the advent of stone, both tombs and temples, which previously had been built of sun-dried brick, began to be constructed of the newer material, but the houses, not only those of the poorer classes, but also those of the nobles and

¹ *Exodus*, v, 7-18.

² E. G. Acheson, *Journal Society of Chemical Industry*, xxix (1910), p. 246; A. H. Drummond, *op. cit.*, xxxviii (1919), p. 439 R.

³ W. M. Flinders Petrie, *Kahun, Gurob and Hawara*, p. 26; Pl. IX.

⁴ Carnarvon and Carter, *Five Years' Explorations at Thebes*, p. 31; Pl. XXII; Carter and Newberry, *The Tomb of Thoutmôsis IV*, pp. 3-4; J. E. Quibell, *The Tomb of Yuua and Thuiu*, *Cat. Gén. du Musée du Caire*, p. 61.

⁵ P. E. Newberry, *The Life of Rekhmara*, p. 38; Pl. XXI.

even the palaces of the Pharaohs, still continued to be made of brick, and it is for this reason that the houses and palaces have perished, while the tombs and temples remain, sun-dried brick being a much less enduring material than stone and also one that lends itself more readily than large blocks of stone to the building requirements of the modern inhabitants.

Burnt bricks, although used in Mesopotamia at a very early date,¹ were not employed in Egypt, so far as is known, before the time of the Roman occupation of the country.

STONE

Egypt is the home of stone working and possesses both the oldest and largest stone buildings in the world. This activity in stone on a large scale and at so early a period was due partly to the fact of the country being very rich in stone and partly to the further fact that copper tools for working it were available. The earliest examples of the use of stone for building purposes that can accurately be dated are of the First Dynasty, namely, the lining and roofing with roughly cut slabs of limestone of a number of small chambers in a tomb of that date at Saqqâra² and a pavement of roughly dressed granite slabs in the tomb of Semti at Abydos.³

Less exactly dated, but certainly of the archaic period, are the natural blocks of undressed, or only roughly dressed, sandstone employed for walls, pavements, facing work and a tomb chamber at Hierakonpolis near Edfu in Upper Egypt⁴ and the limestone lining and flooring of a protodynastic tomb near Qâw, also in Upper Egypt.⁵

Of the Second Dynasty there are two inscribed limestone lintels from tombs at Saqqâra⁶; a limestone room in the tomb

¹ L. W. King, *A History of Sumer and Akkad*, pp. 3, 21, 22, 89, 91; L. Delaporte, *Mesopotamia*, pp. 175, 177; C. L. Woolley, *The Excavations at Ur*, *The Antiquaries Journal*, VII (1927), p. 387.

² J. E. Quibell, *Excavations at Saqqara* (1912-14), pp. 3, 5.

³ W. M. Flinders Petrie, *The Royal Tombs of the Earliest Dynasties*, II, pp. 9-10; Pl. LVIA.

⁴ J. E. Quibell and F. W. Green, *Hierakonpolis*, II, pp. 3-7, 14, 51.

⁵ G. Brunton, *Gau and Badari I*, pp. 14-15.

⁶ J. E. Quibell, *op. cit.*, p. 10.

of Khasekhemui at Abydos¹ and an inscribed grey granite door jamb from a temple of the same Pharaoh at Hierakonpolis.²

Of the Second or Third Dynasty are the rough limestone slabs used for roofing and for portcullises in several tombs at Saqqâra.³

In the Third Dynasty the increased use of stone for building is very marked, especially in Lower Egypt, where it culminates in the very fine buildings discovered a few years ago at Saqqâra. Examples of stone work of this dynasty that may be mentioned are in Upper Egypt, a limestone room in the tomb of Neter-Khet (Zoser) at Beit Khallâf, not far from Abydos,⁴ the stone of which is stated to be 'carefully dressed,' and the limestone of the tomb of Hen-Nekht (Sa-Nekht)⁴ and of three other tombs⁴ also at Beit Khallâf. In Lower Egypt are the large blocks of granite in the unfinished pyramid at Zawyet el-Aryân, between Giza and Abusîr; the limestone of the pyramid of Zoser (the step pyramid) at Saqqâra and its temenos wall⁵; the adjoining limestone colonnade and temples⁵; the granite chamber in the step pyramid⁵ and the granite chamber in the neighbouring great tomb,⁵ all of which date from the early part of the dynasty.

An inscription on the Palermo stone states that a temple of stone was erected in the reign of Neneter of the Second Dynasty, but the remains of this have not been found.⁶

From the examples given, it becomes almost certain that the use of stone for building purposes originated in Lower Egypt in connexion with the necropolis of Memphis⁷ at Saqqâra, where it was undoubtedly perfected, and since there were associations as early as the First Dynasty⁸ between Memphis and Abydos and in the Third Dynasty between Memphis and

¹ W. M. Flinders Petrie, *op. cit.*, p. 13; Pl. LVII.

² J. E. Quibell and W. M. Flinders Petrie, *Hierakonpolis*, I, p. 6; Pl. II.

³ J. E. Quibell, *op. cit.*, pp. 1, 3, 10, 15, 17, 29, 40, 41.

⁴ J. Garstang, *Mabâsna and Bêt Khallâf*, pp. 3-15; Pls. VI, VII, XVII.

⁵ C. M. Firth, in *Annales du Service*, xxv (1925), pp. 149-59; *op. cit.*, xxvi (1926), pp. 97-101; *op. cit.*, xxvii (1927), pp. 105-11; *op. cit.*, xxviii (1928), pp. 81-8.

⁶ H. R. Hall, in *Cambridge Ancient History*, I, p. 276.

⁷ The name Memphis was not given to the city until the Sixth Dynasty (H. R. Hall, *op. cit.*, p. 273).

⁸ Pieces of two alabaster jars found by C. M. Firth at Saqqâra bear the name of Aha, a king of the early part of the First Dynasty, and a piece of

Beit Khallâf, the stone working in the south seems to have been merely a reflection of that from the north.

The principal kinds of stone employed for building in ancient Egypt were limestone, sandstone and, to a much less extent, granite with the occasional use of alabaster, basalt and quartzite, all of which may now be considered.

*Limestone*¹

Limestone consists essentially of calcium carbonate (carbonate of lime), but contains varying, though usually small, proportions of other ingredients, such as silica, clay, oxide of iron and magnesium carbonate and it differs considerably in quality and hardness. It occurs extensively in Egypt, the hills bordering the Nile Valley from Cairo to a little beyond Esna, a distance of about 500 miles, being formed of this material and it also occurs sporadically from Esna to within a short distance of Aswan, for example on the west bank of the river at Faras near El-Silsila and on the east bank at Rangama near Kôm Ombo; it is also found in other localities, as at Mex near Alexandria and in the neighbourhood of Suez.

Examples of the early use of limestone as a building material have already been given, and it continued to be employed for tombs and temples until about the middle of the Eighteenth Dynasty, when, though still occasionally used, as in the temples of Seti I² and Ramesses II³ at Abydos, both of the Nineteenth Dynasty, it largely gave place to sandstone. In addition to the use of limestone as a building material, a very large number of tombs of all periods were cut out of the living limestone rock.

a cup of rock crystal has the name of Semti, a later Pharaoh of the same dynasty (Antiquities Department, communication to daily press, *Egyptian Gazette*, May 16th, 1931), both of whose tombs are at Abydos. The more recent find of a very large number of stone vessels (many inscribed) in the step pyramid will probably confirm and extend the knowledge of this connexion between the north and the south.

¹ See also p. 365.

² Most of the walls are of limestone, as also the pavement and portions of the pillars in the entrance courts, but two of the walls, most of the pillars and the roof are of sandstone.

³ Sandstone, granite and alabaster were all employed, the sandstone for pillars, the granite for door-frames and the alabaster for the sanctuary.

Although limestone was generally quarried in the immediate vicinity of where it was required, the better qualities were obtained from special localities, and such quarries are often referred to in the ancient records, for example, those at Tura (Troja),¹ Ma'sara,² Ayan (Tura-Ma'sara)³ and Gebelein,⁴ which may be seen to-day with the ancient inscriptions on the walls.

At Tura the inscriptions date from the Twelfth Dynasty to the Thirtieth Dynasty,^{5, 6, 7, 8, 9} but there are references on the monuments to the Tura quarries as early as the Fourth Dynasty¹⁰ and the stone was employed extensively at Saqqâra from the Third Dynasty and at Gîza from the Fourth Dynasty. In the Cairo Museum there is a letter on papyrus (No. 49623) of the Sixth Dynasty written by an officer in charge of certain Tura quarrymen. The quarries are still being worked on a large scale.

At Ma'sara the inscriptions range from the Eighteenth Dynasty to the Ptolemaic period.^{7, 8, 9, 10, 11} The quarries are still productive.

At Gebelein the inscriptions are from the Nineteenth Dynasty to the Roman period.^{12, 13} The quarries are not now worked.

Other limestone quarries in which there are ancient inscriptions are also known, thus at El-Barsha there are quarries in one of which is a cartouche of the Thirtieth Dynasty¹⁴; in a

¹ J. H. Breasted, *Ancient Records of Egypt*, v (Index), pp. 101, 154.

² J. H. Breasted, *op. cit.*, v (Index), pp. 87, 154.

³ J. H. Breasted, *op. cit.*, v, pp. 73, 154.

⁴ J. H. Breasted, *op. cit.*, v, pp. 78, 154.

⁵ J. H. Breasted, *op. cit.*, I, 739; II, 799, 875.

⁶ W. M. Flinders Petrie, *A History of Egypt*, I (1923), p. 192; II (1924), p. 36; III (1918), pp. 166, 375, 385.

⁷ S. Birch, *Tablets found in the Quarries at Turah and Massara*, in *The Pyramids of Gizeh*, H. Vyse, III, pp. 93-103.

⁸ G. Daressy, *Inscriptions des Carrières de Tourah et Mâsarab*, in *Annales du Service*, XI (1911), pp. 257-68.

⁹ W. Spiegelberg, *Die Demotischen Inschriften der Steinbrüche von Tura und Ma'sara*, in *Annales du Service*, VI (1905), pp. 219-33.

¹⁰ J. H. Breasted, *op. cit.*, II, 26.

¹¹ W. M. Flinders Petrie, *op. cit.*, III, p. 375.

¹² J. H. Breasted, *op. cit.*, III, 209; IV, 627.

¹³ G. Daressy, *Les Carrières de Gebelein et le Roi Smendes*, in *Recueil de travaux*, x (1888), pp. 133-8.

¹⁴ G. W. Fraser, in *El Bersheh*, P. E. Newberry, II, p. 56.

quarry at El-Amârna there is a cartouche of the Eighteenth Dynasty¹; on the west of the Nile opposite Luxor there are small quarries in which until comparatively recently, when they were destroyed, were three inscriptions, one of the Twenty-sixth Dynasty and two of Roman date²; at Abydos there are two ancient quarries, one to the south and the other to the north-west, in the former of which it is stated there are cartouches and in the latter, cut at one of the entrances, is a sacred eye; near the ancient Ptolemais there are quarries of fine-grained limestone in which are inscriptions dating from the end of the Thirtieth Dynasty to the early part of the Roman imperial epoch³; at Qâw (Antaeopolis) there are quarries with demotic inscriptions⁴ and at Beni Hasan ancient quarries extend for at least three miles along the cliffs.⁵

As an example of stone having been quarried on the spot where it was required, that for the Giza pyramids may be mentioned. The stones of which the greater part of these pyramids are built is very characteristic, being highly fossiliferous and containing innumerable nummulites and is identical with that of the plateau on which the pyramids stand and several of the large depressions near-by are the quarries from which this stone was obtained, although being now partly buried in sand, they are not easily recognizable, the hollow in which the sphinx is, for example, being one of the quarries. It should be mentioned that many years ago (in 1883) Petrie denied this and stated,⁶ 'But no quarryings exist on the western side in the least adequate to yield the bulk of either of the greater Pyramids; and the limestone of the western hills is different in its character to that of the Pyramid masonry, which resembles the qualities usually quarried on the eastern shore. It seems, therefore, that the whole of the stones were quarried in the cliffs of Turra and Masara and brought across to the

¹ W. M. Flinders Petrie, *Tell el-Amarna*, p. 4.

² W. M. Flinders Petrie, *Qurneh*, p. 15.

³ J. de Morgan, U. Bouriant et G. Legrain, *Note sur les carrières antiques de Ptolémaïs*, in *Mem. de la Mission arch. française au Caire*, VIII (1892), pp. 353-79.

⁴ W. M. Flinders Petrie, *Antaeopolis*, pp. 15, 16.

⁵ Somers Clarke and R. Engelbach, *Ancient Egyptian Masonry*, p. 15.

⁶ W. M. Flinders Petrie, *The Pyramids and Temples of Gizeh*, p. 209.

selected site.' As Petrie wrote before any of the quarries had been uncovered it is not strange that they should have been overlooked, but it is singular that no mention is made of the very large amount of stone that was removed anciently in levelling the foundation plateau and in cutting back the rock on the north and west sides of the pyramid of Chephren, which stone was almost certainly used in the construction of the pyramid and would have formed a not inconsiderable proportion of the whole quantity employed. Of the Mycerinus quarry Reisner says ¹ ' . . . the quarry south-east of the Third Pyramid, which is nearly of sufficient size to have supplied the whole ' that is ' the core of the pyramid, the foundation platforms of the temples and the massive core walls,' which 'were all of this stone ' (i.e. the local nummulitic limestone).

The casing stones of the two larger pyramids, those of Cheops and Chephren, and the casing stone of the upper portion of the third pyramid, that of Mycerinus, although limestone, was of a different and much finer-grained quality than the rest of the stone and free from fossils, as may be seen from the few blocks that remain, and, as this stone does not occur in the immediate neighbourhood, it must have been brought from elsewhere and almost certainly from the Tura quarries on the opposite side of the river, and the statements of Herodotus,² Diodorus,³ Strabo⁴ and Pliny⁵ that the stone for the construction of the pyramids was brought across the river from quarries in the Arabian hills is true only of that for the casing. At that time, however, the casing of the first and second pyramids was intact and all that could have been seen was the Tura stone on the outside and there would have been no indication that the stone underneath was different. The step pyramid of Saqqâra, too, is built of stone quarried on the spot and was cased with a better quality of stone, probably also from Tura.

The Old Kingdom tombs and temples, for which limestone was employed, were mostly situated in the neighbourhood of the capital, Memphis, where limestone of good quality, suitable for building, carving and painting upon, was plentiful, whereas when building on a large scale shifted south in the Eighteenth

¹ G. A. Reisner, *Mycerinus*, p. 69.

³ I, 5.

⁴ XVII, I, 34.

² II, 8, 124.

⁵ XXXVI, 17.

and following Dynasties, immense quantities of stone were required, at first in the vicinity of Thebes, which had succeeded Memphis as the capital, and later at places still farther south.

Although limestone occurs abundantly near Thebes, it is mostly of poor quality and ill-adapted for building purposes. To this there are two exceptions, already mentioned, namely, a little north of Elwat el-Debbân, near the Valley of the Tombs of the Kings, on the west of the Nile opposite Luxor and at Gebelein, almost midway between Luxor and Esna, in both of which places there is a comparatively small amount of better quality stone that was worked anciently.

In consequence, therefore, of the great scarcity of good quality limestone near Thebes, when building stone was required in large quantities, the choice was between transporting limestone from a distance or employing a substitute. Whether the first of the alternatives was ever adopted is uncertain, but the fine-grained limestone of the walls of the mortuary temple of Mentuhotep at El-Deir el-Bahari and that of the temple of Amenophis I at Karnak appears too good a quality to be local. At Abydos, too, the limestone used in the temples of Seti I and Ramesses II respectively, which is of a particularly good quality, may not be local, although there are two ancient quarries of fairly good stone in the neighbourhood.

*Sandstone*¹

Sandstone consists essentially of quartz sand derived from the disintegration of older rocks, cemented together by very small proportions of clay, calcium carbonate, oxide or iron or silica.

As already mentioned, the hills bordering the Nile valley from Cairo to near Esna are of limestone, but beyond Esna this limestone is replaced by sandstone, which in turn forms the hills on both sides of the river until near Aswan and again beyond Aswan from Kalâbsha to Wâdi Halfa.² The most northerly occurrence of sandstone is near El-Sabaîa, between Esna and El-Mahamîd.

Although not generally employed until about the middle of

¹ See p. 371.

² From Aswan to Kalâbsha, a distance of about 40 miles, the hills are of granite and other igneous rock.

the Eighteenth Dynasty, sandstone was not an entirely new and untried material, as it had already been used on a small scale in the form of natural blocks of undressed or only roughly dressed material at Hierakonpolis as early as the archaic period¹ and it was employed also in the Eleventh Dynasty for the foundations, pavements, pillars, architraves, roof slabs and the walls in the hypostyle hall in the mortuary temple of Mentuhotep at El-Deir el-Bahari.² The use of sandstone on a large scale, however, began about the middle of the Eighteenth Dynasty and practically all the existing temples in Upper Egypt are of this material, for example, the following-named (the earliest of which dates from the Eighteenth Dynasty and the latest from the Roman period), Luxor,³ Karnak, El-Qurna,⁴ the Ramesseum,⁵ Medînet Habu, Deir el-Medîna, Dendera, Esna, Edfu, Kôm Ombo, Philae, those in Nubia (i.e. between Aswan and Wâdi Halfa) and those in the oases of the western desert.

The exceptions to the general use of sandstone are the mortuary temple of Hatshepsût at El-Deir el-Bahari (Eighteenth Dynasty) and the temples of Seti I and Ramesses II respectively at Abydos (Nineteenth Dynasty), the first being almost entirely of limestone⁶ and the other two containing much limestone.

In addition, however, to the exceptions just mentioned, other temples in Upper Egypt, of which now only a few remains exist, were built in part of limestone, as for instance the mortuary temple of Amenophis I⁷ (early Eighteenth Dynasty)

¹ See p. 45.

² Somers Clarke, in *Deir el Bahari*, II, E. Naville, pp. 13-14.

³ An inscription in the limestone quarry of Gebelein states that in the reign of Nesubenebbed (Smendes) of the Twenty-first Dynasty stone from the quarry was employed to repair a wall round the Luxor temple (J. H. Breasted, *op. cit.*, IV, 627).

⁴ Limestone was used for the bottom courses of several walls and in a few other places. An inscription in the limestone quarry of Gebelein states that in the reign of Seti I stone from the quarry was employed in Seti's mortuary temple at El-Qurna (J. H. Breasted, *op. cit.*, III, 209).

⁵ Limestone was employed for the columns in a side hall and for part of the pavement.

⁶ A number of architraves in the north colonnade of the middle terrace are of sandstone, which is also present in the foundations of the two lower colonnades and of the south-west supporting wall.

⁷ Sandstone was also employed, but probably only for later additions.

on the west of the Nile opposite Luxor ; the temple of the same pharaoh at Karnak ; the temple of Tuthmosis III¹ (middle Eighteenth Dynasty) situated to the north-east of the Ramesseum ; the temple of Amenophis II² (middle Eighteenth Dynasty) between that of Tuthmosis III and the Ramesseum ; the temple of Tuthmosis IV² (latter part of Eighteenth Dynasty), to the south-east of the Ramesseum and the temple of Mer-en-Ptah¹ (Nineteenth Dynasty) almost midway between the Ramesseum and Medînet Habu.

The principal ancient sandstone quarries were at El-Silsila, which is situated on the Nile about 40 miles north of Aswan between Edfu and Kôm Ombo. The quarries, which are very extensive, bear inscriptions dating from the Eighteenth Dynasty down to Greek and Roman times.^{3, 4, 5} It seems probable that the earliest inscriptions, namely those of the Eighteenth Dynasty, represent the date when the quarry was first exploited, since the sandstone of the Eleventh Dynasty temple at El-Deir el-Bahari (the principal example of the earlier use of sandstone), judging from its colour and texture, was not from these quarries. Its place of origin, however, is unknown, though suggestions have been made that it was from Aswan,⁶ but though sandstone occurs at Aswan,⁷ the author has not been able to find there the particular quality used in the Mentuhotep temple.

Other ancient sandstone quarries are at Sirâg,⁸ about 20 miles south of Edfu and at Qirtâs, in Nubia, about 25 miles south of Aswan, which latter as shown by inscriptions in the quarry, was worked from about the Thirtieth Dynasty until Roman times, chiefly for the stone used in the construction of the temple at Qirtâs and the temples of Philae.^{9, 10}

¹ A considerable amount of sandstone was also employed.

² Probably largely sandstone.

³ A. E. P. Weigall, *A Guide to the Antiquities of Upper Egypt*, 1913, pp. 358-60.

⁴ J. H. Breasted, *op. cit.*, II, 348, 932 ; III, 205, 552, 627 ; IV, 18, 702.

⁵ W. M. Flinders Petrie, *A History of Egypt*, III (1918), pp. 8, 119, 143,

144.

⁶ Somers Clarke, *op. cit.*, p. 14.

⁷ J. Ball, *The First or Aswan Cataract of the Nile*, pp. 65-6.

⁸ W. F. Hume, *Explan. Notes to the Geol. Map of Egypt*, p. 47.

⁹ J. L. Burckhardt, *Travels in Nubia*, pp. 113-16.

¹⁰ A. E. P. Weigall, *op. cit.*, pp. 496-7.

At El-Kâb much of the sandstone employed for the temples was quarried in the neighbouring hills and is of very poor quality, but that used in the temple of Tuthmosis III is better and was possibly obtained from elsewhere.¹

The stone for the temples of Nubia was quarried in the immediate vicinity of where it was required, and there are small ancient quarries at Dabôd,² Tôfa³ and Beit el-Wâli.⁴

Granite⁵

Granite is the name of a large class of crystalline rocks of igneous origin, that are not homogeneous in structure like limestone and sandstone, but are composed of a number of different minerals, chiefly quartz, felspar and mica, the abundance of the quartz constituting one of the characteristic features of granite. The principal individual minerals, being readily visible to the naked eye, the rock has a granular structure, from which its name is derived.

Granite was employed for building from the early dynastic period onwards, generally as a lining material for chambers and passages and for door-frames. Examples of its early use have already been mentioned,⁶ but to these may be added its employment in the interior of the three large pyramids at Giza; for facing part at least of the lowest course of the pyramid of Chephren; for facing the greater part (about two-thirds) of the pyramid of Mycerinus, where a considerable portion is still in position; in the interior of the pyramid temples of both Chephren and Mycerinus and for the construction of the small temple near the sphinx (valley temple of Chephren), all of which are of Fourth Dynasty date. Examples of its later use are certain door-frames in many of the temples of Upper Egypt.

The use of granite in the pyramid of Chephren is referred to by Herodotus, who says 'the lowest layer of it is of variegated Ethiopian stone'⁷ and the granite facing of the pyramid of Mycerinus is mentioned by several of the classical writers, thus Herodotus states that 'as far as the half of its height it is of

¹ Somers Clarke, *El Kâb and its Temples*, in *Journal, Egyptian Archaeology*, VIII (1922), pp. 20, 24, 29.

² A. E. P. Weigall, *op. cit.*, p. 492.

³ Weigall, *op. cit.*, p. 501.

⁴ Weigall, *op. cit.*, p. 510. ⁵ See p. 363. ⁶ See pp. 45-6. ⁷ II, 127.

Ethiopian stone' ¹; Diodorus says, 'The walls for fifteen stories high were of black marble like that of Thebes, the rest was of the same stone with the other pyramids' ²; Strabo writes that, 'from the foundation nearly as far as the middle, it is built of black stone . . . which is brought from a great distance; for it comes from the mountains of Ethiopia, and being hard and difficult to be worked, the labour is attended with great expense' ³ and Pliny states that 'it is built of Ethiopian stone.' ⁴

In most instances the granite used anciently for all purposes was the coarse-grained red variety from Aswan, but grey granite (generally very dark grey, also from Aswan) was employed as well, though only to a comparatively small extent. Thus, in the First Dynasty tomb already mentioned, there is grey granite mixed with the red ⁵; the Second Dynasty temple door jamb from Hierakonpolis is of grey granite. Judging from the fragments of dark grey granite that lie about the ruins of the pyramid temple of Chephren this stone was employed in its construction and a few blocks of dark granite are present in Chephren's valley temple; among the red granite of the pyramid of Mycerinus, both outside and inside, there is an occasional block that is dark grey and in the temple adjoining this pyramid there is a considerable amount of both red granite and dark grey granite; dark grey granite, as well as red granite, was also employed for door-frames in some of the Upper Egyptian temples. Although for Egyptological purposes it is sufficient to call this grey stone 'dark grey granite,' strictly it is a hornblende-biotite granite. The *syenites* of Pliny, a name first used by this writer to describe a rock quarried at Syene ⁶ (the ancient name for Aswan), which stone he states was employed for certain columns in the Egyptian Labyrinth, ⁷ was almost certainly the ordinary Aswan red granite, as Pliny explains that *syenites* had formerly been called *pyrrhopæcilon* (i.e. spotted with red). The term syenite is now, however, applied to a granitic rock, resembling in appearance dark grey granite, in which mica is partly replaced by hornblende (which gives a dark colour to the stone) and in which quartz is absent or present only in small proportion.

¹ II, 134.

² I, 5.

³ XVII, I, 33.

⁴ XXXVI, 17.

⁵ W. M. Flinders Petrie, *The Royal Tombs of the Earliest Dynasties*, II, p. 10.

⁶ XXXVI, 13.

⁷ XXXVI, 19.

Granite is widely distributed in Egypt and occurs plentifully at Aswan, in the eastern desert and in Sinai and to a small extent in the western desert.

The principal ancient granite quarries are at Aswan in two localities, one about a kilometre south of the town and the other on the east side of the plateau, but other and smaller quarries also exist on the islands of Elephantine and Sehel and in a few other places.¹ Quarries at Aswan,² Elephantine³ and at the First Cataract⁴ are all referred to in the ancient records as early as the Sixth Dynasty, also a quarry at Ibhet,⁵ which has not been identified, but which must have been in the neighbourhood of Elephantine. The use of granite for building and other purposes is constantly mentioned.

In addition to the granite of Aswan and neighbourhood, the only other granites known to have been worked anciently are the red granite of Wâdi el-Fawâkhîr⁶ (a continuation of Wâdi Hammamât), between Qena and El-Quseir, the date of the working of which is unknown, but probably late (Weigall says Roman)⁷ and the black and white granite quarried for export by the Romans at Mons Claudianus in the eastern desert.⁸

*Alabaster*⁹

Ordinarily the name alabaster means calcium sulphate (gypsum), but the material employed so extensively in ancient Egypt, which is also called alabaster, and which probably has the prior claim to the name, is an entirely distinct material of very similar appearance, but different chemical composition and consists of calcium carbonate. Geologically, Egyptian alabaster is calcite, though sometimes erroneously called aragonite, which is of the same composition, but of different crystalline form and different specific gravity. Whether aragonite is found in

¹ J. Ball, *A Description of the First or Aswan Cataract of the Nile*, 1907, p. 74.

² J. H. Breasted, *op. cit.*, I, 42.

³ I, 322.

⁴ I, 324.

⁵ I, 321, 322.

⁶ T. Barron and W. F. Hume, *The Topog. and Geol. of the Eastern Desert of Egypt, Central Portion*, pp. 49, 118, 119, 265.

⁷ A. E. P. Weigall, *Travels in the Upper Egyptian Deserts*, p. 50.

⁸ T. Barron and W. F. Hume, *op. cit.*, pp. 39, 264.

⁹ See p. 356.

Egypt is not known, but its occurrence has not been reported and all the alabaster examined by the author has been calcite.

The name alabaster, therefore, will be used in the present book as always meaning calcite, a compact crystalline form of calcium carbonate, white or yellowish white in colour, translucent in thin sections and frequently banded.

Alabaster was employed as a subsidiary building material chiefly for lining passages and rooms, particularly shrines, from early dynastic times to at least as late as the Nineteenth Dynasty, for example, possibly for a chamber in the step pyramid at Saqqâra¹ (Third Dynasty); for a chamber in the valley temple of Chephren (Fourth Dynasty), judging from the blocks lying about, in the pyramid temple of Chephren; for the pavements of a corridor, a large court and a passage respectively in the pyramid temple of Unas at Saqqâra² (Fifth Dynasty); for the pavement of the central part of the pyramid temple of Teti at Saqqâra (Sixth Dynasty)³; for the sanctuary of a temple of Sesostri I⁴ at Karnak (Twelfth Dynasty); for the sanctuaries of the temples of Amenophis I,^{4, 5, 6, 7} Amenophis II⁸ and Tuthmosis IV^{4, 9} respectively (all Eighteenth Dynasty and at Karnak); for lining a corridor leading to the sacred lake at Karnak (Eighteenth Dynasty) and for the sanctuary of the temple of Ramesses II at Abydos (Nineteenth Dynasty).

Alabaster occurs in Sinai,¹⁰ where, however, there is not any evidence of its ever having been worked, and in various localities in the desert on the east side of the Nile. Beginning with the most northerly of these occurrences and proceeding southwards they are situated respectively as follows, (a) in the Wâdi Gerrawi near Helwan, where there are quarries dating from the Old Kingdom¹¹; (b) in the Cairo-Suez desert, where the stone was

¹ C. M. Firth, *Annales du Service*, xxv (1925), pp. 153-4.

² Firth, *op. cit.*, xxx (1930), p. 186.

³ J. E. Quibell, *Excavations at Saqqara* (1907-8), p. 19.

⁴ H. Chevrier, *Annales du Service*, xxviii (1928), p. 120.

⁵ Chevrier, *op. cit.*, xxii (1922), pp. 238-40.

⁶ Chevrier, *op. cit.*, xxiii (1923), p. 112.

⁷ Chevrier, *op. cit.*, xxiv (1924), p. 56.

⁸ Chevrier, *op. cit.*, xxiv, 57.

⁹ Chevrier, *op. cit.*, xxiv, 59-60.

¹⁰ H. J. L. Beadnell, *The Wilderness of Sinai*, p. 83.

¹¹ W. M. Flinders Petrie and E. Mackay, *Heliopolis, Kafr Ammar and Shurafa* pp. 39-40.

worked for a short period in modern times, but where there is no evidence of ancient working¹; (c) in the Wâdi Moathil (a branch of the Wâdi Sennur), almost due east of Maghâgha, where there are not any signs of ancient working, but where there was extensive quarrying in the time of Mohammed Ali^{2, 3, 4}; (d) in the district extending from about Minya to a little south of Asyût, where there are signs of working in many places and where the most important of the ancient alabaster quarries are situated. These, which are frequently referred to in the ancient records, are at Hatnub, about 15 miles east of El-Amârna, and in them are inscriptions beginning in the Third Dynasty and continuing until the Twentieth Dynasty.^{5, 6, 7} In one small alabaster quarry near El-Amârna there are inscriptions of the Nineteenth Dynasty⁸ and in another a rude relief, probably of Roman age.⁹ A quarry, also in the same district, but farther south, situated in the Wâdi Asyût, was worked at the beginning of the Eighteenth Dynasty and was reopened in the time of Mohammed Ali.^{3, 10, 11}

Egyptian alabaster was known to Theophrastus (fourth to third century B.C.); Pliny (first century A.D.) and Athenaeus (second to third century A.D.). Theophrastus states¹² that alabaster was found in Egypt in the neighbourhood of Thebes, where it was dug up in large masses: Pliny writes in one place¹³ that alabaster was found in the vicinity of Thebes and in another

¹ T. Barron, *The Topog. and Geol. of the District between Cairo and Suez*, pp. 20, 93.

² W. F. Hume, *Explan. Notes to the Geological Map of Egypt*, p. 46.

³ Dr. Hasan Sadek, Controller, Mines and Quarries Department, Egypt.

⁴ R. Fourtau, *Voyage dans la partie septentrionale du Desert Arabique*, in *Bull. Soc. Khéd. Géogr.*, Cairo, 1900, p. 548.

⁵ J. H. Breasted, *op. cit.*, I, 7, 305, 690.

⁶ G. W. Fraser, *Hatnub*, in *Proc. Soc. Bibl. Arch.*, XVI (1893-4), pp. 73-82.

⁷ W. M. Flinders Petrie, *A History of Egypt*, I (1923), pp. 45, 56, 100, 102, 114, 125, 161.

⁸ W. M. Flinders Petrie, *Tell el-Amarna*, pp. 3-4.

⁹ P. Timme, *Tell El-Amarna*, pp. 45-7.

¹⁰ A. E. P. Weigall, *The Alabaster Quarries of Wady Assiout*, in *Annales du Service*, XI (1911), p. 176.

¹¹ W. F. Hume, *The Alabaster Quarry of Wâdî Asiut*, in *Cairo Scientific Journal*, VI (1912), p. 72.

¹² *History of Stones*, xv.

¹³ xxxvi, 12.

place¹ that it was obtained from Alabastron, the position of which he refers to elsewhere² in a very confused manner; thus after mentioning the mountains that form 'the boundaries of the province of Thebais' he says, 'On passing these we come to the towns of Mercury (i.e. probably Hermopolis), Alabastron, the town of Dogs and that of Hercules. . . .' If Alabastron was anywhere near Hermopolis it cannot have been far from Hatnub and these quarries, therefore, may have been known by repute to Pliny. Athenaeus states³ that the Egyptians sometimes built walls of alabaster. The uses of alabaster for purposes other than for building will be dealt with separately.⁴

*Basalt*⁵

Basalt is a black,⁶ heavy, compact rock, often showing tiny glittering particles: it consists of an aggregate of various minerals, which in true basalt are too fine-grained to be distinguished separately, except by means of a microscope, the coarser varieties of rock where the separate minerals can be recognized with the naked eye being dolerite. There is, however, no hard and fast dividing line between the two, a coarse-grained basalt being a fine-grained dolerite and the material so largely employed in ancient Egypt, being relatively coarse-grained, though generally called basalt, is strictly a fine-grained dolerite. However, as the name basalt for this stone has become so firmly established in the literature of Egyptology and as it is neither misleading nor entirely wrong, it is suggested that it should be retained and it will be used in the present book.

Basalt was largely employed in the Old Kingdom as a material for pavements, thus the pavement in the pyramid temple of Cheops at Giza (all that now remains of the temple) is of basalt; also pavements of a court, a causeway, two small chambers and a small offering place in a Fifth-Dynasty mortuary temple at Saqqâra⁷ and pavements, and possibly other parts

¹ xxxvii, 54.

² v, 11.

³ *The Deipnosophists*, v, 26.

⁴ See p. 356.

⁵ See pp. 356-7.

⁶ The colour is brown when the stone is weathered and partly decomposed.

⁷ C. M. Firth, *Annales du Service*, xxix (1929), pp. 65, 68.

of the buildings, in the mortuary temples of two Fifth-Dynasty temple-pyramids at Abusîr¹ (between Giza and Saqqâra).

Basalt is widely distributed in Egypt and occurs at Abu Za'bal, which is situated about midway between Cairo and Bilbeis (Bubastis); to the north-west of the Giza pyramids (beyond Kirdâsa in the Abu Rwâsh area); in the Cairo-Suez desert; in the Fayûm; a short distance to the south-east of Samâlût in Upper Egypt; at Aswan; in the Baharia Oasis; in the eastern desert and in Sinai.²

The basalt employed in such large quantity during the Old Kingdom in the necropolis stretching from Giza to Saqqâra was probably local and all the available evidence points to the Fayûm as the source. Thus, in the Fayûm, within easy reach of this necropolis, there is a basalt quarry approached by a made road, and, therefore, manifestly worked on a large scale and, near the quarry, is a small temple probably of Old Kingdom date and there is no evidence of the ancient quarrying of basalt near Cairo, except in the Fayûm. Moreover, the basalt employed in the Old Kingdom is found to be more nearly like that from the Fayûm than that from Abu Za'bal. Also during the Old Kingdom, another material, gypsum, employed for mortar and plaster in the Giza necropolis, was almost certainly procured, in part at least, from the Fayûm and probably certain gypsum vases found at Giza were also obtained from the Fayûm.³

The Controller, Department of Mines and Quarries (Dr. H. Sadek), states that there is no evidence of any working of the Abu Rwâsh basalt, which would have been the nearest source of supply, and that 'the quality is poor and decomposed.'⁴

*Quartzite*⁵

Quartzite is a hard, compact variety of sandstone that has been formed from ordinary sandstone by the deposition of

¹ L. Borchardt, (a) *Das Grabdenkmal des Königs Ne-User-Re*, pp. 7, 8, 56, 57, 142, 151; (b) *Das Grabdenkmal des Königs S'Abu-Re*, pp. 7, 15, 24, 32, 34, 37, 64, 93, 96.

² For references, see A. Lucas, *Egyptian Predynastic Stone Vessels*, in *Journal, Egyptian Archaeology*, xvi (1930), p. 202. The information about the Samâlût basalt was kindly given by Mr. O. H. Little, Director, Geological Survey, Cairo.

³ For more details and references, see A. Lucas, *op. cit.*, pp. 203-5.

⁴ Letter dated 7th Dec. 1933.

⁵ See p. 370.

crystalline quartz between the sand grains; that is to say, it is silicified sandstone; it varies considerably both in colour and in texture and may be white, yellowish or various shades of red and either fine-grained or coarse-grained.

Quartzite occurs in various localities in Egypt, notably at Gebel Ahmar,¹ which is situated close to Cairo on the north-east; also between Cairo and Suez²; on the Bir Hammam-Moghara road³ and at Gart Muluk³ in the Wâdi Natrûn depression, both in the western desert; capping the Nubian sandstone on the east of the Nile to the north of Aswan⁴ and in Sinai.⁵

Only a few examples are known to the author of the use of quartzite as a building material, namely, for the thresholds of several doorways in the pyramid temple of Teti at Saqqâra (Sixth Dynasty)⁶ and for lining the sepulchral chamber in the Hawara pyramid (Twelfth Dynasty)⁷ and in both the north and south pyramids at Mazghuna (Twelfth Dynasty).⁸

The Gebel Ahmar quarries are still worked and until recently there were fragmentary ancient inscriptions in them,^{9, 10} but these now no longer exist. This quarry and the stone from it are mentioned several times in the ancient records.¹¹ The quartzite to the north of Aswan has also been quarried extensively and in one place there is a hieroglyphic inscription, as also an ancient ramp leading down from the quarry.⁴

¹ T. Barron, *The Topog. and Geol. of the District between Cairo and Suez*, p. 56.

² T. Barron, *op. cit.*, pp. 61, 62, 103, 104.

³ W. F. Hume, *Explan. Notes to the Geological Map of Egypt*, p. 16.

⁴ Information kindly supplied by Mr. G. W. Murray, Desert Survey of Egypt.

⁵ T. Barron, *The Topog. and Geol. of the Peninsula of Sinai (Western Portion)*, pp. 163, 199.

⁶ J. E. Quibell, *Excavations at Saqqara (1907-1908)*, p. 19.

⁷ W. M. Flinders Petrie, (a) *Kahun, Gurob and Hawara*, p. 16, and (b) *A History of Egypt*, I (1923), p. 196.

⁸ W. M. Flinders Petrie, G. A. Wainwright and E. Mackay, *The Labyrinth, Gerzeh and Mazghuneh*, pp. 44-9, 51-4.

⁹ L. Borchardt, *Inscripfrfragmente vom Gebel Ahmar*, in *Zeitschrift für Ägyptische Sprache und Altertumskunde*, 47 (1910), p. 161.

¹⁰ G. Daressy, *Graffiti de la Montagne Rouge*, in *Annales du Service*, XIII (1914), pp. 43-7.

¹¹ J. H. Breasted, *op. cit.*, v (Index), pp. 78, 130.

Quarrying

The quarrying of stone could not, and did not, begin until it was rendered possible by the advent of metal (copper) tools, when for the first time the use of stone on a large scale for building purposes became practicable, the stone used earlier for vases and other comparatively small objects having been procured from blocks, that having been detached from the cliffs by natural processes, were easily accessible, or from boulders found in the ancient dry water courses and at the sides of the river in the cataract areas, and, even after the quarrying of soft stone had become common, one at least of the hard stones, namely granite, was almost certainly obtained for a considerable period from boulders. The method of quarrying stone is inferred from the evidence still to be seen in the ancient quarries, more particularly where there are blocks only partly detached.

Soft Stone

The quarrying of soft stone (alabaster, limestone and sandstone) has been described by Somers Clarke and Engelbach¹; by Petrie^{2, 3} and by Reisner.⁴ It was by isolating a block on four sides by means of trenches cut in the rock and then detaching it from below by the action of wooden wedges or wooden beams wetted with water. The tools employed were metal chisels (which were of copper until the Middle Kingdom when bronze was introduced and then either of copper or bronze until the advent of iron); wooden mallets and stone hammers.^{5, 6}

Hard Stone

As already mentioned, it seems highly probable that the quarrying of hard stone from the rock mass was not practised until some considerable time after the quarrying of soft stone had become common, but that granite, the most generally used

¹ Somers Clarke and R. Engelbach, *Ancient Egyptian Masonry*, pp. 12-22.

² W. M. Flinders Petrie, *The Arts and Crafts of Ancient Egypt*, p. 70.

³ W. M. F. Petrie, *Qurneh*, pp. 15-16. ⁴ G. A. Reisner, *Mycerinus*, pp. 69-70.

⁵ Somers Clarke and R. Engelbach, *op. cit.*, p. 17.

⁶ G. A. Reisner, *op. cit.*, pp. 69, 232, 236.

of the hard stones, was still obtained from large boulders (which are plentiful at Aswan at the present day and which have been used in recent times to supply part of the granite required for the dam) and that it was not until the Middle Kingdom and later, when objects such as huge obelisks and colossal statues, were required that the quarrying of this stone from the living rock was resorted to. The two other hard stones employed for building, namely basalt and quartzite, may also have been obtained at first from fallen or easily detached blocks.

The ancient quarrying of granite and quartzite has been studied by Engelbach,^{1, 2} who states that the method used for granite consisted essentially of pounding with balls of dolerite and the use of wedges, the slots for which were cut with a metal tool, and that pounding and wedging were also employed for quartzite with the additional use of another tool, possibly some sort of metal pick.

Stone Working

The ancient method of working stone after it had been quarried may partly be deduced from the tool marks left on objects, particularly on statues, of which a number of unfinished examples are known, but partly also from illustrations of some of the processes that are depicted on certain tomb walls. The subject has been studied by Somers Clark,³ Engelbach,⁴ Petrie,⁵ Platt,⁶ Reisner⁷ and others.

The ancient Egyptian stone statues, particularly those in such hard materials as diorite, granite, quartzite and schist, have long been a source of admiration on account of their excellent workmanship and of wonder and speculation as to the nature of the tools used. Various methods by means of which

¹ R. Engelbach, *The Problem of the Obelisks*, pp. 23, 26, 34, 36, 42.

² Somers Clarke and R. Engelbach, *op. cit.*, pp. 23-33.

³ Somers Clarke, *Cutting Granite*, in *Ancient Egypt*, 1916, pp. 110-13.

⁴ Somers Clarke and R. Engelbach, *op. cit.*, pp. 194, 198, 202-4.

⁵ W. M. Flinders Petrie, (a) *On the Mechanical Methods of the Ancient Egyptians*, in *Journ. Anthropol. Inst.*, XIII (1883); (b) *The Pyramids and Temples of Gizeh*, pp. 173-7; (c) *The Arts and Crafts of Ancient Egypt*, pp. 69-82.

⁶ A. F. R. Platt, *The Ancient Egyptian Methods of Working Hard Stones*, in *Proc. Society Bibl. Arch.*, XXXI (1909), pp. 172-84.

⁷ G. A. Reisner, *op. cit.*, pp. 116-18, 232.

it is thought these hard stones were worked, have been, and from time to time still are, described, these including the use of steel (a very frequent explanation) or of copper or bronze tools set with diamonds or other hard precious stones, and it is refreshing to read in a recent publication by Reisner that 'the technical processes used in carving hard stone statues were of the simplest sort, as must be the case when steel is not available.'¹ Reisner summarizes the principal operations, which were ^{1, 2} :

1. Pounding with a stone. Possibly represented in a Fifth Dynasty tomb at Saqqâra³ and in an Eighteenth Dynasty tomb at Thebes.⁴

2. Rubbing with stones held in the hand, probably accompanied by the use of an abrasive powder. Represented in a Fifth Dynasty tomb at Saqqâra³ and in an Eighteenth Dynasty tomb at Thebes.⁴

3. Sawing by means of a copper blade, accompanied by the use of an abrasive powder. No representations of this are known.

4. Boring by means of a tubular drill and an abrasive powder, the drill being a hollow tube of copper turned either by rolling between the hands or by means of a bow or with a crank handle. No representations of this are known. A tubular drill was also used for boring out stone vessels, particularly cylindrical jars,⁵ and Petrie states⁶ that a borer of this kind was used for 'beginning the hollowing out of the great diorite bowls' and also for 'more upright vessels,' of which examples in basalt and alabaster are given.

In this connexion another form of boring tool employed for hollowing out stone vessels may be mentioned, namely, a kind of centre-bit provided with an eccentric handle and two heavy weights, the handle probably being of wood and the drill being flint, often crescent-shaped, of which numerous specimens have been found at Saqqâra and elsewhere, as also a large number

¹ G. A. Reisner, *op. cit.*, pp. 117-18.

² Slightly modified by the author in the manner of presentation.

³ G. Steindorff, *Das Grab des Ti*, Pl. 134.

⁴ P. E. Newberry, *The Life of Rekhmara*, Pl. XX.

⁵ G. A. Reisner, *op. cit.*, p. 118.

⁶ W. M. Flinders Petrie, *Journ. Anthropol. Inst.*, XIII (1883), pp. 6-7 (off-print).

of holes bored with such flints, some at Abusîr¹ and others in blocks of limestone of Third Dynasty date at Saqqâra,² these latter being possibly trials by apprentices learning the use of the drill. This drill is represented in various tomb scenes, for example, in a Fifth Dynasty tomb at Saqqâra,⁶ in a Twelfth Dynasty tomb at Deir el-Gabrâwi³ and in two Eighteenth Dynasty tombs at Thebes.^{4, 5}

5. Drilling with a copper or stone point with an abrasive powder. In three Eighteenth Dynasty tombs at Thebes a drill is shown being rotated by means of a bow for drilling beads^{6, 7, 8} and in a fourth tomb for drilling some unknown object.⁹

6. Rubbing with a copper (?) point with abrasive powder. The evidence for this is doubtful. The implement is shown in an Eighteenth Dynasty tomb at Thebes.¹⁰

In connexion with the working of hard stones, too much stress is usually laid upon the use of chisels, and those who think that steel must have been used point out that copper and bronze chisels, no matter to what extent they have been hardened by hammering, will not cut such hard stones as diorite, granite and schist, and that they cannot be used with an abrasive powder. This is freely admitted, and such chisels were certainly not employed, except for soft stones. But for the use of saws and drills, including tubular drills, there is ample evidence in the marks that remain on the stones on which they have been used.¹¹ Thus saw marks exist on the basalt of the pavement of the pyramid temple of Cheops¹²; on the red

¹ L. Borchardt, *Das Grabdenkmal des Königs Ne-User-Re*, pp. 142-3; Figs. 123-4.

² Illustrated by Somers Clarke and R. Engelbach, *op. cit.*, Figs. 248-9, facing p. 204.

³ N. de G. Davies, *The Rock Tombs of Deir el Gabrawi*, I, Pl. XIII.

⁴ P. E. Newberry, *The Life of Rekhmara*, Pl. XVII.

⁵ N. de G. Davies, *The Tomb of Two Sculptors at Thebes*, Pl. XI.

⁶ P. E. Newberry, *op. cit.*, Pl. XVII.

⁷ N. de G. Davies, *The Tomb of Two Sculptors at Thebes*, Pl. XI.

⁸ N. de G. Davies, *The Tomb of Two Officials of Tutmosis the Fourth*, Pl. X.

⁹ N. and N. de G. Davies, *The Tombs of Menkheperresonb Amenmose and Another*, p. 25; Pl. XXX.

¹⁰ P. E. Newberry, *op. cit.*, Pl. XX.

¹¹ The evidence was first recognized and published by Petrie.

¹² W. M. Flinders Petrie, *The Pyramids and Temples of Gizeh*, pp. 46, 84, 106.

granite sarcophagi of Cheops and Chrephren respectively ¹; on the red granite sarcophagus of Hordedef (Fourth Dynasty) ^{2, 3} found by Reisner at Giza; on the lid of the grey granite sarcophagus of Meresankh ³; on the back of one of the triads of Mycerinus ³ and on an unfinished alabaster statue of this same Pharaoh.⁴ The marks of tubular drills are found on an alabaster statue of Mycerinus ³ and also on an unfinished statue of the same monarch ⁵; on the well-known diorite statue of Chephren ³ and on an obsidian head of Tuthmosis III from Karnak.³ Tubular drills were also used for making sockets in the granite of the pyramid temple of Mycerinus to take the ends of door-posts and for bolts,⁶ and Petrie gives many additional examples of tubular drill holes and cores.⁷ Examples of drilling with a copper or stone point, where the drill holes are still clearly visible and unmistakable, exist on two pieces of inscribed stone vases (Third Dynasty) from the step pyramid at Saqqâra. The inscriptions have been described and illustrated by Gunn⁸ and the objects are in the Cairo Museum, one (Gunn's No. 4, Pl. I; Museum No. J. 55257) being part of a diorite vase and the other (Gunn's No. 1, Pl. III; Museum No. J. 55273) being part of a vase described by Gunn as diorite, which, however, is not diorite, but probably dolomitic limestone.

The saws and drills, except the 'centre-bit' mentioned, must have been of copper ⁹ until the Middle Kingdom (about 2000 B.C.) when bronze tools were first used¹⁰ and then either of copper or bronze until iron came into general use,¹¹ and, as neither copper nor bronze is sufficiently hard to cut such stones as basalt, diorite, granite, quartzite and schist, a harder material than the metal was required to do the work, which must have been used either in the form of cutting points (teeth) or as a loose powder.

¹ W. M. Flinders Petrie, *The Pyramids and Temples of Gizeh*, pp. 46, 84, 106.

² G. A. Reisner, *op. cit.*, p. 241.

³ In the Cairo Museum.

⁴ G. A. Reisner, *op. cit.*, pp. 111, 116-17.

⁵ Reisner, *op. cit.*, pp. 111, 117.

⁶ G. A. Reisner, *op. cit.*, p. 86.

⁷ See reference No. 5 (a) and (b), p. 63.

⁸ Battiscombe Gunn, *Inscriptions from the Step Pyramid*, in *Annales du Service*, xxviii (1928), pp. 159, 162.

⁹ The hardening of copper is discussed on p. 171.

¹⁰ For bronze and the date of its introduction into Egypt, see pp. 174-8.

¹¹ The use of iron in Egypt is discussed on pp. 194-8.

The principal advocate of fixed cutting points is Petrie, who stated in 1883¹ that 'The material of these cutting points is yet undetermined; but only five substances are possible: beryl, topaz, chrysoberyl, corundum or sapphire, and diamond. The character of the work would certainly seem to point to diamond as being the cutting jewel; and only the considerations of its rarity in general, and its absence from Egypt, interfere with this conclusion, and render the tough uncrystallized corundum the more likely material.' In 1925, however, Petrie wrote,² 'The cutting of granite was done by means of jewelled saws . . . and jewelled tubular drills. What cutting points were used is unknown, but it seems impossible for corundum to do such cutting through quartz.'

With respect to the tubular drills, Petrie states³ that ' . . . not only did the Egyptians set cutting jewels round the edge of the drill tube . . . but . . . they also set cutting stones in the sides of the tube, both inside and out . . . '

The hardest rock that the ancient Egyptians cut was quartz, either as quartzite (which is wholly quartz) or as quartz crystals in granite and other rocks.⁴ The hardness of quartz on the Mohs scale is 7. The five stones mentioned by Petrie, as alone being possible to use for cutting the Egyptian rocks, all have a hardness greater than that of quartz, beryl being 7.5 to 8; topaz, 8; chrysoberyl, 8.5; the gem forms of corundum (ruby, sapphire), 9, and diamond, the hardest of all stones, 10.

Although beryl occurs in Egypt, there is no evidence that it was known before the Greek epoch and the strongest improbability that it was ever obtained in the large quantity that would have been required had it been used for cutting hard stones. The other stones enumerated are not found in Egypt, the topaz

¹ W. M. Flinders Petrie, *The Pyramids and Temples of Gizeh*, p. 173.

² W. M. F. Petrie, *Ancient Egyptians (Descriptive Sociology)*, p. 58.

³ W. M. F. Petrie, *Journ. Anthropol. Inst.*, XIII (1883), p. 7 (off-print).

⁴ This refers to working on a large scale, but even on a small scale the hardest stone was quartz in the form of amethyst and rock crystal. Such stones as agate, carnelian, chalcedony, flint and jasper, which were also worked, consist of silica (of which quartz is the crystalline form) and have much the same hardness as quartz. The beryl, which is slightly harder than quartz, was not cut, but always left in the natural (hexagonal) crystalline form.

(*topazos*) of Strabo¹ and Pliny² (which they state was obtained from an island in the Red Sea) being probably the modern peridot, which has a hardness of only 6·5 and which, therefore, is much softer than topaz and too soft to cut quartz. Also there is no evidence that the Egyptians were acquainted with any of these stones until a very late period if ever they did know them.

In the author's opinion, to suppose the knowledge of cutting these gem stones to form teeth and of setting them in the metal in such a manner that they would bear the strain of hard use, and to do this at the early period assigned to them, would present greater difficulties than those explained by the assumption of their employment.

All the purposes of the hard precious stones, however, could be secured by the use of emery (whether emery was used will be discussed later) which is an impure and less hard variety of corundum³ and, despite Petrie's misgivings, the author ventures to think that it is sufficiently hard to cut quartz. This material was originally obtained from some of the islands in the Grecian archipelago, notably Naxos, but is now mined on a very large scale on the mainland of Asia Minor, and as it occurs abundantly it is comparatively cheap, and by the wasteful process of simply breaking it up into coarse powder and picking out pieces of the required size (which would have been impossible with precious stones on account of their rarity and price) it is conceivable that a supply could have been obtained suitable for teeth for saws and drills. There would, however, have been the difficulty of fixing the teeth and, although such work is done at the present day, there is no evidence and very little probability that it was possible 5000 years ago. But were there indeed teeth such as postulated by Petrie? The evidence advanced to prove their presence is as follows⁴:

¹ XVI, 4, 6.

² VI, 34; XXXVII, 32.

³ The abrasive power of emery depends largely upon the proportion of crystalline aluminium oxide present, but partly also on its physical condition; its hardness is about 8 and the principal constituent, other than aluminium oxide, is iron oxide.

⁴ W. M. Flinders Petrie, (a) *Journ. Anthropol. Inst.*, XIII (1883), pp. 2, 15-16 (off-print); (b) *The Pyramids and Temples of Gizeh*, pp. 173-4; (c) *The Arts and Crafts of Ancient Egypt*, p. 73.

(a) A cylindrical core of granite grooved round and round by a graving point, the grooves being continuous and forming a spiral, with in one part a single groove that may be traced five rotations round the core.

(b) Part of a drill hole in diorite with seventeen equidistant grooves due to the successive rotation of the same cutting point.

(c) Another piece of diorite with a series of grooves ploughed out to a depth of over one-hundredth of an inch at a single cut.

(d) Other pieces of diorite showing the regular equidistant grooves of a saw.

(e) Two pieces of diorite bowls with hieroglyphs incised with a very free-cutting point and neither scraped nor ground out.

But, if a coarse abrasive powder had been used with soft copper saws and drills, it is highly probable that pieces of the abrasive would have been forced into the metal, where they might have remained for some time, and any such accidental and temporary teeth would have produced the same effect as intentional and permanent ones. This possibility is not admitted by Petrie, who states¹ that 'it seems physically impossible that any particle of a loose powder could become so imbedded in a soft metal by the mere accidents of rubbing that it could bear the immense strain . . . needed to plough out a groove of any considerable depth in such a hard material as quartz.' Judging, however, from the analogy of modern 'lapping,' in which a fine abrasive powder is employed with a soft metal (copper, lead or soft alloy), and some of which becomes embedded in the metal during use,² it is believed that in the ancient method of working some of the abrasive would have been forced into the metal, which was the softest of the three substances present (the copper, the abrasive and the stone).

In the discussion that followed Petrie's paper, Mr. (afterwards Sir) John Evans stated³ that in his opinion the grooves were caused by the drilling tool having been a tube of soft material employed with some hard gritty substance, and that 'it was not improbable that the spiral grooves on the cores

¹ W. M. Flinders Petrie, *Journ. Anthropol. Inst.*, p. 3 (off-print).

² In certain cases the abrasive powder is rubbed into the 'lap' (a disk of soft metal) by means of a hard pebble.

³ W. M. Flinders Petrie, *Journ. Anthropol. Inst.*, pp. 18-19 (off-print).

were made either in introducing the tube charged with fresh grinding material into the recess or in withdrawing it when clogged.'

In Petrie's discussion of the evidences (*c*) and (*e*), the expressions used 'ploughing out one-hundredth inch thick of quartz at a single cut,'¹ and 'As the lines are only one-one-hundred-and-fiftieth inch wide . . . it is evident that the cutting point must have been harder than quartz,'² are somewhat misleading since the material referred to by Petrie was not quartz, but diorite, which is not so hard; and since diamond dust is used for cutting diamonds, presumably, therefore, quartz powder might be employed for cutting quartz.

Referring to the schist triads of Mycerinus, Reisner states³ that 'Some of the signs . . . show slips of a sharp point.'

In the author's opinion the abrasive material was a loose powder used wet, and Petrie states⁴ that 'There is no doubt that sawing and grinding with loose powder was the general method.'

That a hard abrasive powder embedded in or used with a soft material will cut hard stones is well known, and it is stated that in South America a certain tribe of Indians at one time were in the habit of drilling rock crystal by means of a shoot of the wild plantain fed with quartz sand and water,⁵ which is only another illustration of the fact that an abrasive powder can cut a substance as hard as itself, as is proved in the case of the diamond which as already mentioned is abraded by its own dust.

Respecting the nature of the abrasive powder there is much difference of opinion, Petrie being sure that it was emery⁶ and Reisner supposing it to have been either emery⁷ or pumice⁷ while the author ventures to suggest that it was neither, but was finely-ground quartz sand.

¹ W. M. Flinders Petrie, *Journ. Anthrop. Inst.*, p. 2 (off-print).

² W. M. F. Petrie, *The Pyramids and Temples of Gizeh*, pp. 173-4.

³ G. A. Reisner, *op. cit.*, p. 118 (6).

⁴ W. M. Flinders Petrie, *The Arts and Crafts of Ancient Egypt*, pp. 73-4.

⁵ See discussion on Petrie's paper in *Journ. Anthrop. Inst.*, p. 20 (off-print); also J. D. McGuire, *A Study of the Primitive Methods of Drilling*, no date given.

⁶ W. M. Flinders Petrie, *The Arts and Crafts of Ancient Egypt*, pp. 74, 79.

⁷ G. A. Reisner, *op. cit.*, pp. 116, 117, 118.

The manner of working stone depicted on certain tomb walls has already been referred to, and beyond the scenes mentioned the Egyptian records are silent on the matter. The classical writers, however, give some little information on the subject.

Theophrastus,¹ after enumerating the precious and semi-precious stones known in his day, states that 'some of the stones . . . are of so firm a texture, that they . . . are not to be cut by instruments of iron, but only by other stones.' This author makes no mention of emery, but he describes pumice,² though he does not refer to any use of it as an abrasive.

Vitruvius³ just mentions the cutting of stone with a toothed saw, but gives no details of the operation.

Pliny devotes two chapters⁴ to the cutting and polishing of stone, chiefly 'marble,' and manifestly the use of abrasive powders was well known in his day, as also the nature of the function they performed, since he says that the cutting of the stone 'though apparently effected by the aid of iron, is in reality effected by sand; the saw acting only by pressing upon the sand . . .' Among the materials he mentions as being employed for cutting stone are emery (sand of Naxos); 'sand' from India, Egypt and Nubia and certain stones from Cyprus and Armenia and, for putting the final polish on 'marble,' a material from Egypt (Thebaic stone) and pumice are both recommended.

Pumice is a light spongy lava with a cellular structure, composed chiefly of aluminium silicate. It is obtained principally from the Lipari islands in the Mediterranean, but may be picked up in small quantity on the northern shore of Egypt. No figure for the hardness of pumice can be traced, but it is almost certainly less than 7 and probably much less, and if so it could not be used to cut quartz. No evidence is known to the author of the use of pumice in ancient Egypt, though a piece of Sixteenth Dynasty date was found at Sedment,⁵ and two lumps of Nineteenth Dynasty date were found at Gurob.⁶

In the absence of any direct positive evidence respecting the

¹ *History of Stones*, LXXII, LXXV-LXXVII.

² *Op. cit.*, XXXIII-XL.

³ *De Architectura*, II, 7, 1.

⁴ XXXVI, 9-10.

⁵ W. M. Flinders Petrie and G. Brunton, *Sedment I*, p. 16.

⁶ W. M. Flinders Petrie, *Illahun, Kabun and Gurob*, p. 23.

nature of the abrasive powder employed anciently in Egypt, the negative evidence may be considered and is as follows :

(a) Beyond a statement, that has not been confirmed, that some of the sand at Aswan contains 15 per cent of emery,¹ there is no knowledge of the occurrence of this material in Egypt.

(b) A few objects² (a plummet ; a vase ; a tool ; three small blocks ; a piece and several hones) stated to consist of emery and mostly of early date, have been found in Egypt, but that the material is indeed emery in every instance requires confirmation and the carving of it into objects seems a contra-indication of its use as an abrasive.

(c) It is much more likely that any abrasive used should have been a local product, rather than an imported material, provided that a substance existed in the country capable of doing the work required, and the author believes that quartz sand, which occurs in great abundance almost everywhere in Egypt, will abrade diorite and quartz, which were the hardest stones the ancient Egyptians worked, the latter of which, in the form of rock crystal, being cut by certain South American Indians with quartz sand.

(d) If emery were the abrasive employed, this can only mean that its properties were familiar at the time of the Third and Fourth Dynasties (nearly 3000 B.C.), not only in Egypt, where stone working on a large scale was only just beginning, but also in its country of origin (Greece), where stone working was then unknown, which seems most improbable.

(e) Whatever abrasive was employed, it must have been used on a very large scale and vast quantities of it must have been consumed, and hence it must have been very plentiful and cheap, which could hardly have been the case had it been imported.

(f) The Egyptians had been working hard stones on a small scale for amulets, beads, mace heads, palettes, vases and other purposes for at least several hundred years before stone was employed for building and it seems reasonable to suppose that the use of sand as an abrasive would have been familiar to them and that when an abrasive was required on a large scale

¹ G. A. Wainwright, *Balabish*, p. 38.

² For references, see p. 219.

the same material would have been employed. That sand was sometimes used as an abrasive is proved by the finding in a vase grinder's workshop of Old Kingdom date 'a quantity of sand that had been used as an abrading material.'¹

(g) In all discussions respecting the manner of cutting hard stones in ancient Egypt it should be remembered that the large number of workmen; the long hours worked in the day; the time occupied in the work and particularly the skill, practice and infinite patience of the workmen are all important factors that should be taken into account.

The much-debated questions of the hardening of copper² and of the possible use of steel at an early date³ will be discussed in connexion with the metals.

MORTAR

The mortar employed in ancient Egypt before Graeco-Roman times was of two kinds, depending upon the nature of the construction, namely, clay for use with sun-dried bricks and gypsum for use with stone. The former is still used for sun-dried bricks at the present day and is the most suitable material for the purpose, but gypsum is not now employed as a mortar, having given place to the more recent lime-sand mixture or to the still more modern cement.

No instance of the use of lime mortar in Egypt, or of lime in any form, is known to the author as occurring before the time of Ptolemy I (323 to 285 B.C.)⁴ when it has been found and, from the few specimens analysed,^{4, 5} it appears to have been, as is only to be expected, of much the same composition as the lime mortar of to-day.

The reason for preferring gypsum to lime, although limestone is very plentiful in the country, even more plentiful than gypsum and also more accessible, was doubtless owing to the scarcity

¹ J. E. Quibell and F. W. Green, *Hierakonpolis*, II, p. 17.

² See p. 171.

³ See p. 199.

⁴ Renato Salmoni, *Sulla Composizione di alcune antiche malte egiziane*, in *Atti e Memorie della R.^a Accademia di Scienze Lettere ed Arti in Padova*—a. 1933 (XI), Vol. XLIX. This reference the author owes to Mr. Gilbert Bagnani who kindly gave him a reprint of the article.

⁵ See p. 415.

of fuel, lime, as will be shown later when dealing with plaster, requiring a very much higher temperature for burning, and hence more fuel than gypsum, and it was not until the advent of the Greeks and Romans, both of whom knew lime in Europe, where gypsum is useless for outdoor work on account of the wet climate, that lime-burning was practised in Egypt.

Clay Mortar

Clay mortar is simply the ordinary Nile alluvium, consisting of clay and sand, which for use is mixed with sufficient water to bring it to the required consistency.

Gypsum Mortar

The mortar employed in ancient Egypt for stone, as already stated, was of gypsum, which was necessarily burnt and slaked before use. In much of the stone work, however, the individual blocks were so large and many, especially the facing stones, were dressed so truly that mortar as a binding or pointing material was not necessary and, although employed, it was largely as a cushion between the stones to prevent the edges from being damaged while they were being placed in position and as a suitable material on which the large unwieldy blocks of stone could slide and by means of which, therefore, in the absence of pulleys and cranes, they could be adjusted and placed accurately in position.

PLASTER

The ancient Egyptian wall plaster was similar in composition to the mortar and consisted of the same two materials, namely, clay and gypsum, and, although both kinds were doubtless employed in house decoration, the houses have largely perished; and except fragments of painted plaster found among the ruins of the palace of Amenophis III,^{1, 2, 3} situated to the south

¹ A. E. P. Weigall, *A Guide to the Antiquities of Upper Egypt*, 1913, pp. 290-1.

² Robb de P. Tytus, *A Preliminary Report on the Re-excavation of the Palace of Amenhotep III.*

³ G. Daressy, *Le Palais d'Amenophis III*, in *Annales du Service*, IV (1903), pp. 165-70.

of the temple of Medīnet Habu, and among the ruins of the palaces and houses at El-Amârna,¹⁻⁵ practically all the plaster that now remains is that to be found in tombs and temples. A third kind of plaster, used, not for walls, but for covering wood before gilding and painting, will be described later.⁶

Clay Plaster

The use of clay plaster dates from predynastic⁷ and early dynastic⁸ times. The quality of the plaster varies considerably, but in the main two principal kinds may be recognized, one coarse and generally, if not always, mixed with straw and the other, possibly limited to the Theban necropolis, of finer quality, employed both with and without straw, often as a finishing coat to the coarser kind. Both qualities were usually covered with gypsum plaster in order to provide a better surface for painting, a notable exception, however, being at El-Amârna, where not only in the private houses, but also in the palaces, the painting was done directly on the clay plaster.

The coarse quality consists of ordinary Nile alluvium, which is essentially a mixture of clay and sand in varying proportions, with generally a small natural admixture of calcium carbonate (carbonate of lime) and occasionally a small proportion of gypsum, which latter however, is purely accidental and has no binding property, as it has not been burnt.

The finer quality is a natural mixture of clay and limestone, both in a very fine state of division, found in hollows and pockets at the foot of the hills and plateaux, from which it has been washed out by the occasional rain storms that occur. This is

¹ T. E. Peet and C. L. Woolley, *The City of Akhenaten*, 1.

² F. G. Newton, *Excavations at El-Amarnab*, 1923-4, in *Journal Egyptian Archaeology*, x (1924), pp. 289-98.

³ H. Frankfort, *Preliminary Report on the Excavations at Tell El-Amarnab*, 1926-7, in *Journal Egyptian Archaeology*, xiii (1927), pp. 209-18.

⁴ H. Frankfort, *Preliminary Report on the Excavations at El-Amarnab*, 1928-9, in *Journal Egyptian Archaeology*, xv (1929), pp. 143-9.

⁵ J. D. S. Pendlebury, *Preliminary Report of Excavations at Tell El-Amarnab*, 1930-1, in *Journal Egyptian Archaeology*, xvii (1931), pp. 233-43.

⁶ See p. 296.

⁷ J. E. Quibell and F. W. Green, *Hierakonpolis*, II, p. 21.

⁸ W. M. Flinders Petrie, *The Royal Tombs of the First Dynasty*, I, p. 9.

still employed locally at the present day, under the name of *bîb*, as a finishing coat to sun-dried brick and to coarse clay plaster.

Gypsum Plaster

This is the characteristic wall plaster of ancient Egypt and is known from early dynastic times and no evidence whatever can be found of the use of lime before the Ptolemaic period,¹ the plaster frequently termed 'lime plaster' being always gypsum except at a late date.

The great use of gypsum plaster was to provide for the walls and ceilings of houses, palaces, tombs and temples a suitable surface for painting upon. Where the wall was plastered with clay, this was generally coated with gypsum plaster, and where clay plaster was not used gypsum plaster was employed for the purpose of covering up faults and irregularities in the stone and of smoothing the surface before painting.

Gypsum, being a natural material, varies considerably both in colour and in composition. The colour may be white, different shades of grey, light brown, or even occasionally pink. This latter, however, is merely a surface coloration and is adventitious, being due to chemical changes that have taken place in the iron compounds of the plaster in the course of thousands of years. When the colour is grey, this is generally owing to the presence of small particles of unburnt fuel.

Occasionally the plaster used as a finishing coat, which is white or practically white, contains a very large proportion of calcium carbonate and very little gypsum and, although this may be a poor quality gypsum containing the calcium carbonate naturally, it may be an artificial mixture, additional calcium carbonate having possibly been added in order to produce a lighter colour in plaster that was not white enough for the purpose required. Sometimes the surface coating is so thin as to be merely a distemper or whitewash and consists essentially of calcium carbonate, which may or may not contain a trace of gypsum, which, however, is probably simply an impurity and not the binding material, which may have been size, although whitewash adheres fairly well to limestone without a binder.

¹ See p. 73.

Gypsum occurs plentifully in Egypt in two conditions, one a rock-like formation, which is found to the west of Alexandria ; in the district between Ismailia and Suez ; in the Fayûm and near the Red Sea coast ; and the other in scattered masses of loosely-aggregated crystals, which have merely to be dug up from just below the surface of the limestone desert ; and it is this latter that was, and still is, so largely used for making plaster. At the present time it is worked in the vicinities of both Cairo and Alexandria and in the district stretching south from Cairo to Beni-Suef, but there are small local deposits in other places. As thus found, gypsum is never pure, but contains varying proportions of calcium carbonate and quartz sand, together with small amounts of other ingredients. The presence of the calcium carbonate, which is readily disclosed by chemical analysis, has led those who are not familiar with Egyptian gypsum and who only know the purer European article, to imagine that it is due to an intentional admixture with lime, which in course of time has become converted into carbonate by natural processes, as happens in the case of lime mortar. In the same manner the presence of quartz sand to those who only know of sand in this connexion as a deliberate addition to mortar and plaster is equally confusing and conveys a wrong impression. Ancient Egyptian plaster of the kind under consideration is crude gypsum that has been burnt, powdered and slaked, and any calcium carbonate and sand it contains are not artificial additions, but impurities derived from the raw material in which they occur naturally.

Some little of the gypsum mortar and much of the plaster used in the Giza pyramids and adjacent tombs and in the tombs at Saqqâra are of particularly good quality, one specimen analysed by the author being 99·5 per cent pure and another 97·3 per cent pure, and in view of Miss Caton-Thompson's recent discovery in the Fayûm of an outcrop of pure gypsum that had been worked in early dynastic times,¹ it is almost certain that the better quality gypsum employed at Giza and Saqqâra was from this source.

Chemically, gypsum is calcium sulphate (sulphate of lime)

¹ G. Caton-Thompson, *Recent Excavations in the Fayûm*, in *Man*, XXVIII (1928), p. 110.

containing water in intimate combination. On being heated to a temperature of about 100°C . (212°F .) gypsum loses about three-fourths of its water and forms a substance which has the property of recombining with water to produce a material that sets and finally becomes very hard. The temperature usually employed for burning gypsum varies from about 100°C . (212°F .) to about 200°C . (392°F .), but is generally kept about 130°C . (268°F .), which is a heat readily obtained. This temperature is not sufficiently high to convert any calcium carbonate present into quicklime. The calcined material in the pure form as made in Europe is known as 'plaster of Paris.'

In order that the difference of temperature required to produce lime by burning limestone as compared with that needed to calcine gypsum may be appreciated, it may be mentioned that to convert calcium carbonate into quicklime a temperature of about 900°C . (1652°F .) is required.

WOOD

The principal use of wood in building in ancient Egypt was for the doors, sometimes for the roofs and occasionally for the columns¹ of temples; for the doors and roofs of houses and in certain early predynastic and early dynastic burials for roofing, flooring and lining graves.^{2, 3, 4, 5} Its employment as a building material, however, was not its only, nor its greatest use, and its consideration, therefore, will be deferred to a special chapter.

¹ G. A. Reisner, *Mycerinus*, pp. 40, 47, 67, 92.

² E. R. Ayrton and W. L. S. Loat, *The Predynastic Cemetery at Mahasna*, pp. 3, 6, 7, 21-3.

³ W. M. Flinders Petrie, G. A. Wainwright and A. H. Gardiner, *Tarkhan I and Memphis V*, p. 13.

⁴ W. M. Flinders Petrie, (a) *The Royal Tombs of the First Dynasty*, I, pp. 9-16; (b) *The Royal Tombs of the Earliest Dynasties*, II, pp. 7, 8, 10; (c) *Gizeh and Rifeh*, pp. 2, 3.

⁵ G. A. Reisner, *Early Dynastic Cemeteries of Naga-ed-Der*, pp. 7-10, 18.

CHAPTER IV

COSMETICS, PERFUMES AND INCENSE ¹

COSMETICS

Cosmetics are as old as vanity. In Egypt their use can be traced back almost to the earliest period of which burials have been found, and continues to the present day.

The ancient Egyptian cosmetics included eye-paints, face-paints and oils and solid fats (ointments), all of which are here considered.

Eye-paints

The two commonest eye-paints were malachite (a green ore of copper) and galena (a dark grey ore of lead), the former being the earlier of the two, but being ultimately largely replaced by the latter, which became the principal eye-paint of the country. Both malachite and galena are found in the graves in several conditions, namely, as fragments of the raw material, as stains on palettes and stones on which this was ground when required for use and in the prepared state (*kohl*), either as a compact mass of the finely ground material made into a paste (now dry) or more frequently as a powder. Malachite is known from the Badarian and earliest predynastic period ^{2, 3, 4} until at least the Nineteenth Dynasty,⁵ while galena does not

¹ The greater part of this chapter has been taken from an article *Cosmetics, Perfumes and Incense in Ancient Egypt*, published by the author in *The Journal of Egyptian Archaeology*, xvi (1930).

² G. Brunton, *Qau and Badari*, 1, p. 63.

³ G. Brunton and G. Caton-Thompson, *The Badarian Civilisation*, pp. 31, 41, 85-7, 99, 102, 103, 109.

⁴ W. M. Flinders Petrie, *Prehistoric Egypt*, p. 43.

⁵ A. Wiedermann, *Varieties of Ancient Kohl*, in *Medium*, W. M. Flinders Petrie, pp. 42, 43.

appear before late predynastic times^{1, 2} and continues until the Coptic period.³

The crude form of both malachite and galena was often placed in the graves in small linen or leather bags. The prepared form has been found contained in shells,⁴ in segments of hollow reeds, wrapped in the leaves of plants and in small vases, sometimes reed-shaped.

When *kohl* is found as a mass, as distinct from a powder, this has often manifestly shrunk^{5, 6} and has also sometimes acquired markings from the interior of the receptacle,⁵ from which it is evident that such preparations were originally in the condition of a paste, which has dried. With what the fine powder was mixed to form the paste has not been determined, though, since fatty matter is absent⁵ the use either of water or gum and water seems probable. Fatty matter, however, may have been used in applying the *kohl* to the face.

The composition of the ancient Egyptian *kohl* has been described by various writers, including Wiedermann⁷ (from analyses by Fischer); Florence and Loret⁸ (who quote Fischer's analyses and in addition give particulars of a few earlier ones and of two of their own); Barthoux⁹ (who examined various specimens thought to be *kohl*) and the author¹⁰ (who has analysed a large number of specimens, the results of a few of which have been published).¹¹

The results of the analyses referred to, omitting those of Barthoux, which will be dealt with separately, show that the material was galena in 40 cases out of 61¹² (approximately

¹ W. M. Flinders Petrie, *Prehistoric Egypt*, p. 43.

² G. Brunton, *op. cit.*, pp. 13, 31, 63, 70.

³ A. Weidemann, *Varieties of Ancient Kohl*, in *Medum*, W. M. Flinders Petrie, pp. 42, 43.

⁴ Shells were also employed as receptacles for pigment other than eye-paint.

⁵ A. Wiedermann, *op. cit.*, p. 42.

⁶ Particularly noticeable in the case of dry pastes in shells.

⁷ A. Wiedermann, *op. cit.*, pp. 41-4.

⁸ A. Florence and V. Loret, *Le collyre noir et le collyre vert*, in *Fouilles à Dahchour*, J. de Morgan, 1895, pp. 153-64.

⁹ J. Barthoux, *Les fards, pommades et couleurs dans l'antiquité*, *Congrès Int. de Géog., Le Caire, Avril 1925*, IV (1926), pp. 251-6.

¹⁰ A. Lucas, *Ancient Egyptian Materials*, pp. 59, 104, 146-7.

¹¹ G. Brunton, *op. cit.*, p. 70.

¹² Two with trace of sulphide of antimony and five with carbon.

65.5 per cent), while the rest consisted of respectively carbonate of lead ¹ (2); black oxide of copper (1); brown ochre (5); magnetic oxide of iron (1); oxide of manganese (6); sulphide of antimony ² (1); malachite ³ (4), and chrysocolla, a greenish-blue ore of copper (1).

It will be seen that only one of the specimens consisted of an antimony compound and only three others contained any antimony compound and those only a trace, manifestly present as an accidental impurity. The general idea, therefore, that ancient Egyptian *kohl*, except when it was the green malachite or chrysocolla, always either consisted of or contained antimony or an antimony compound is wrong, and hence it is most misleading to term it *stibium* (an early Latin name for sulphide of antimony, transferred later to the metal), as is sometimes done. The mistake possibly arose from the fact that among the Romans an antimony compound, called by Pliny ⁴ *stimmi* and *stibi*, was employed in eye-cosmetics and eye-medicines.

Lane states ⁵ that the ordinary Egyptian *kohl* of his day consisted of smoke-black (soot) made by burning either a cheap kind of frankincense or the shells of almonds and that the special quality used on account of its supposed medicinal properties contained, besides carbon, a variety of other ingredients, which he enumerates, and which include lead ore, but among which there is no mention of any antimony compound. The present-day Egyptian *kohl* also consists of soot, made, according to Brunton, ⁶ by burning the safflower plant (*Carthamus tinctorius*), and is applied by means of a small wooden, bone, ivory or metal rod, the tip of which is moistened with water and dipped into the powder. These rods only began to appear in the Eleventh Dynasty, before which time the *kohl* was probably put on with the finger. Budge found ⁷ that certain specimens of modern *kohl* from the Sudan consisted of black oxide of

¹ One with trace of sulphide of antimony. ² Nineteenth Dynasty date.

³ One specimen was mixed with resin, but Florence and Loret (*op. cit.*, p. 161) contend that this was a medicinal preparation and not *kohl*.

⁴ XXXIII, 33, 34.

⁵ E. W. Lane, *The Manners and Customs of the Modern Egyptians* (Everyman's Library), p. 37.

⁶ G. Brunton, *op. cit.*, p. 63.

⁷ E. A. Wallis Budge, *The Mummy*, 2nd ed. (1925), p. 259.

manganese. Sonnini in 1780 said that a mixture of blacklead (galena) and lamp black was used.¹

Barthoux's account of the composition of ancient Egyptian *kohl*² is very disappointing, as the dates and particulars of origin of the specimens, as well as the number of each kind examined, are omitted. Although the correctness of the analytical results is not questioned, it is probable that several of the specimens were not eye-paints and that others were not even cosmetics of any sort. The greater proportion consisted wholly or partly of galena; the rest included carbonate of lead; a compound of antimony and lead (the only one in which any antimony compound occurred); vegetable black (i.e. soot obtained by burning vegetable matter); compounds of arsenic (both with and without admixed iron pyrites, some being orange-coloured and probably none of them cosmetics) and chrysocola. Another of the specimens Barthoux suggests may have been composed of bitumen impregnated with aromatic essences. This is described as being chestnut-brown, which is not the colour of bitumen, and apart from the improbability of bitumen having been employed for such a purpose, for which it would be most unsuitable, aromatic essences as separate entities, that could be employed for impregnating other substances, were unknown to the ancient Egyptians, since to obtain them a knowledge of distillation would have been necessary, and this process was not discovered until a very late date.³ A further specimen was rose-coloured and consisted of a mixture of common salt, sodium sulphate, haematite and organic matter, but the composition makes it doubtful whether it was a cosmetic of any sort, and it was almost certainly not an eye-paint. Wax and fatty matter occurred in several instances, but these specimens, although they may have been cosmetics, were probably not eye-paints, since all the specimens of *kohl* analysed by Fischer,⁴ Florence and Loret,⁵ and the author, have been free from these substances. In a few cases, too, resin (sometimes aromatic) was

¹ C. S. Sonnini, *Travels in Upper and Lower Egypt*, trans. H. Hunter, I, p. 263.

² The word employed is '*fards*,' which is used apparently to mean eye-paints and not cosmetics generally.

³ See p. 23.

⁴ A. Wiedermann, *op. cit.*, pp. 41-4.

⁵ Florence and Loret, *op. cit.*, pp. 153-64.

present, but these also are unlikely to have been eye-paints, since all the specimens of *kohl* analysed by others have been free from resin. In one case it is true that a powder examined by von Baeyer consisted of malachite and resin, but Florence and Loret consider this to have been a medicament and not an eye-paint on account of the inscription on the receptacle.¹ Although resin is frequently found in graves, particularly in those of early date, close to or associated with the eye-paint materials malachite and galena, there is no evidence to show that it was used with them, and, as already mentioned, all the prepared eye-paints analysed have been free from resin, except the few specimens reported by Barthoux, and that these were indeed eye-paint needs confirmation. In view of Elliot Smith's statement² that the malachite and resin were ground together on the slate palettes (also frequently found in the graves), a number of experiments were made with specimens of ancient malachite and ancient resin and also with ancient malachite and modern resin (colophony) which were ground together to a very fine powder and applied to the face and in no instance was there any satisfactory adhesion to the skin.

The materials of the early eye-paints, malachite and galena, are both products of Egypt, malachite being found in Sinai and in the eastern desert and galena near Aswan and on the Red Sea coast. The additional materials occasionally employed later, namely carbonate of lead, oxide of copper, ochre, magnetic oxide of iron, oxide of manganese and chrysocolla are also all local products, the only exceptions being compounds of antimony, which, so far as is known, do not occur in Egypt, but which are found in Asia Minor, Persia and possibly also in Arabia.³

According to the ancient records eye-paint was obtained in the Twelfth Dynasty from the Asiatics,⁴ in the Eighteenth Dynasty from Naharin in western Asia⁵ and from Punt,⁶ and in the Nineteenth Dynasty from Koptos.⁷ Although there was

¹ Florence and Loret, *op. cit.*, p. 161.

² G. Elliot Smith, *In the Beginning*, p. 57.

³ R. F. Burton, (a) *The Gold Mines of Midian*, pp. 168, 375, 390; (b) *The Land of Midian*, I, pp. xxii, 194.

⁴ J. H. Breasted, *Ancient Records of Egypt*, I, 620, n.d.

⁵ II, 501.

⁶ II, 265, 272.

⁷ A. Erman, *The Literature of the Ancient Egyptians*, trans. A. M. Blackman, p. 34.

no necessity for the Egyptians to import eye-paint from abroad, since all the materials employed, except the very rarely used antimony compounds, occur naturally in the country, there would not have been any difficulty in obtaining it from Asia, where the various materials also occur. The eye-paint from Koptos that so puzzled Max Müller¹ may well have been galena from the Red Sea coast, but what eye-paint could have been brought from Punt is a question not easily answered. Punt is chiefly associated with odoriferous gum-resins used as incense (which in the list of articles obtained are enumerated separately), but these are not eye-paints, though they were sometimes employed to impart a fragrance to ointments used as cosmetics. It is certainly possible, however, although it seems unlikely, that some mineral substance, not native to Punt (since none likely to have been sent to Egypt is known to occur there) may have reached Egypt by way of Punt, in the same manner as in Roman times, produce from India was carried to ports on the African coast and thence transhipped to Italy. If this were so, the material referred to may have been malachite or galena, which were the principal eye-paints of ancient Egypt and both of which occur in Arabia.^{2, 3}

Face-paints

In addition to painting round the eyes, the ancient Egyptian women probably sometimes also coloured their cheeks, since this is the most reasonable explanation of certain red pigment found in the graves associated with palettes⁴ and as stains on palettes^{5, 6, 7, 8} and stones⁹ on which it was ground for use.

¹ W. Max Müller, *Egyptological Researches*, II, pp. 88-9.

² R. F. Burton, *op. cit.*, (a) pp. 141, 204, 219, 228, 390; (b) I, pp. xi, xxi, xxiii, 55, 66, 75, 76, 267, 269; II, p. 53.

³ R. F. Burton, *op. cit.*, (a) pp. 11, 204, 390; (b) I, pp. xxii, 266, 269; II, pp. 191, 242.

⁴ C. M. Firth, *Arch. Survey of Nubia, Report for 1910-1911*, p. 157.

⁵ W. M. Flinders Petrie, *Prehistoric Egypt*, p. 37.

⁶ W. M. Flinders Petrie and E. Mackay, *Heliopolis, Kafr Ammar and Shurafa*, p. 18.

⁷ G. Brunton and G. Caton-Thompson, *op. cit.*, p. 31.

⁸ J. E. Quibell, *Archaic Objects, Cat. Gén. du Musée du Caire*, I, pp. 226, 227.

⁹ G. Brunton, *op. cit.*, p. 62.

This pigment is a naturally occurring red oxide of iron, generally termed haematite, but which would be more correctly described as red ochre.¹

Oils and Fats

As oils and fats used as cosmetics were frequently scented they will be dealt with as perfumes.

PERFUMES

An important class of ancient Egyptian cosmetics consisted of oils and fats (ointments), and their use is frequently mentioned in the ancient records^{2, 3} and by several of the Greek and Roman writers. That in a hot, dry climate, such as that of Egypt, oils and fats should have been applied to the skin and hair was only natural, and the practice is common in Nubia, the Sudan and other parts of Africa at the present day. The oil was probably of more than one kind, that used by the poorer classes, according to Strabo,⁴ being castor oil, which is still used for this purpose in Nubia. Of solid fats the choice was small, being limited to animal fats.

From purely theoretical considerations alone it is exceedingly probable that fragrant substances were sometimes added to these oils and fats, not only to render them more pleasing, but also to mask the tendency of such materials to become rancid and disagreeable. Fortunately, however, it is not necessary to rely on conjecture as there is definite evidence that such indeed was the case, as will now be shown.

The modern liquid scents and perfumes are solutions in alcohol of various odoriferous principles derived from the flowers, fruits, wood, bark, leaves or seeds of plants, but more generally from flowers. Such perfumes cannot have been known in ancient Egypt at any very early date, since to produce many

¹ Red ochre, which was the only red pigment known in ancient Egypt until very late, was also much employed for painting tombs and other objects, as also by the scribes in writing, and it is found in graves, apart altogether from palettes and from any suggestion of its use in personal adornment.

² J. H. Breasted, *op. cit.*, v (Index), pp. 123, 149.

³ A. Erman, *op. cit.*, pp. 8, 61, 99, 102, 156, 202, 207, 209, 244, 246, 249.

⁴ xvii, 2, 5.

of them, as well as to produce the alcohol to dissolve them, a knowledge of the process of distillation is essential, and this was almost certainly not discovered until a late period, the earliest reference to it that can be traced being one by Aristotle ¹ in the fourth century B.C. Both Theophrastus ² (fourth to third century B.C.) and Pliny (first century A.D.) ³ also mention distillation, and from the methods described it seems clear that the process was then in a primitive and, therefore, presumably early stage.⁴

After alcohol, the next best medium for absorbing and retaining odours is fat or oil, a fact that is largely made use of at the present day to abstract the scent from flowers, the petals of which are placed in layers of solid fat or soaked in oil, the perfume being afterwards removed by means of alcohol, in which condition it is used. This method, at least in its entirety, must have been unknown until the process of separating alcohol by distillation from fluids containing it was discovered, though a partial application of it would have been possible without alcohol, since after the fat or oil had become thoroughly impregnated with the perfume, if the exhausted petals had been picked out or otherwise removed, a scented fat or oil would have remained. A method of this kind was practised by the Greeks in the time of Theophrastus,⁵ the oil most used being that from the Egyptian or Syrian *balanos* ⁶ (*Balanites aegyptiaca*), though olive oil and almond oil were also employed. A similar method was also in use by the Romans of Pliny's day,⁷ various plants being left to steep in oil and then pressed, or sometimes boiled in oil. That a corresponding process was also employed in Egypt seems indicated by Pliny's enumeration of various oils among the constituents of Egyptian unguents.⁸

Egyptian unguents are described by both Theophrastus and Pliny. The former states that one was made from several ingredients, including cinnamon and myrrh ⁹ (the other ingredients not being named) and that a certain perfumer 'had had Egyptian perfume in his shop for eight years . . . and

¹ *Meteorologica*, I, 9, 11; II, 3.

³ XV, 7; XVI, 21-2.

⁵ *Concerning Odours*, IV, 14.

⁸ XIII, 2.

² *Enquiry into Plants*, IX, 3, 1-3.

⁴ See p. 267.

⁶ *Op. cit.*, IV, 15, 16, 19.

⁷ XIII, 2; XV, 7.

⁹ *Op. cit.*, VI, 28.

that it was still in good case, in fact better than fresh perfume.' ¹ Pliny says that Egypt was the country best suited of all for the production of unguents,² and that at one time those most esteemed in the Roman world were from Mendes,³ and he describes the Mendesian unguent as being of a very complex composition, consisting originally of oil of *balanus*,⁴ resin and myrrh, but at a later period containing an Egyptian oil extracted from bitter almonds (*metopium*), olive oil (*omphacium*), cardamoms, sweet rush, honey, wine, myrrh, seed of *balsamum*, galbanum and turpentine resin. This same writer also states that the *myrobalanum*, which grew in the country of the Troglodytae, in the Thebaid and in Ethiopia, yielded an oil particularly suitable for unguents ⁵; also that Egyptian *elate* ⁶ or *spathe* ⁶ and the fruit of a palm called *adipsos* ⁷ were all used in making unguents; he also mentions another Egyptian unguent made from *cyprinum* ⁸ which he states was an Egyptian tree ⁸ and which was probably henna, the flowers of which are odoriferous.

In connexion with henna it may be mentioned that the leaves were possibly used in ancient Egypt, much as they are to-day, in the form of a paste to colour the palms of the hands, the soles of the feet, the nails and the hair. Thus, the Romans certainly employed henna, an Egyptian shrub, for colouring the hair,⁹ and probably therefore the Egyptians also, and Elliot Smith describes the hair of the mummy of Henttawi (Eighteenth Dynasty) as being dyed a brilliant reddish colour, which he suggests was done with henna.¹⁰ Naville states that the finger nails of an Eleventh Dynasty mummy he examined were tinted with henna,¹¹ and Maspero thought that the hands of Ramesses II were stained 'jaune-clair par les parfums.'¹² Elliot Smith, however, suggests that the latter were merely discoloured by the embalming material, which may be the case also with the mummy to which Naville refers, as it almost certainly is with

¹ Concerning Odours, IX, 38.

² XIII, 6.

³ XIII, 2.

⁴ See p. 273.

⁵ XII, 46. Whether this was ben oil (see p. 274) or *balanos* oil (see p. 273) is not clear.

⁶ XII, 62.

⁷ XII, 47.

⁸ XII, 51.

⁹ XXIII, 46.

¹⁰ G. Elliot Smith, *The Royal Mummies*, Cat. Gén. du Musée du Caire, p. 19.

¹¹ E. Naville, *The Eleventh Dynasty Temple at Deir-el-Bahari*, I (1907), p. 44.

¹² G. Elliot Smith, *op. cit.*, pp. 60-1.

the staining of the finger nails of several mummies examined by the author. Newberry has identified twigs of henna from the Ptolemaic cemetery of Hawara.¹

Besides the perfumes from plants already dealt with and in the absence of animal perfumes (the principal being ambergris, civet and musk), for the use of which in ancient Egypt there is no evidence, the only other likely odoriferous substances that remain for consideration are the plant products, resins and gum-resins, for the use of which to perfume oils and fats there is a certain amount of positive evidence, that may now be considered.

The statement of Theophrastus that a certain Egyptian unguent contained myrrh has already been quoted, as also that of Pliny that resin, turpentine resin, myrrh and galbanum entered into the composition of the Mendesian unguent, and to these may be added some slight evidence from the Egyptian records and from the tombs. Although as a rule there is little to suggest that any of the oils, fats and ointments, so frequently mentioned in the records, were scented (there being usually either no description of the material or merely a statement of the purpose for which it was employed), there are several exceptions, namely one instance in which the 'smell of unguents' is referred to,² two others in which 'sweet oil of gums'³ and two in which 'ointment of gums'⁴ respectively are named and, since gums are not odoriferous, but since resins and gum-resins are even to-day often wrongly termed gums, the names suggest a possibility that the oil and ointment referred to may have been perfumed by means of fragrant resins or gum-resins.

From the tombs the evidence leaves much to be desired, but definite facts are gradually being accumulated. Fatty matter has often been found in graves, and this frequently possesses a strong smell,^{5, 6, 7} but probably in no instance is the smell the original one, nor can it reasonably be called a perfume; in

¹ P. E. Newberry, *On the Vegetable Remains discovered in the Cemetery of Hawara*, in *Hawara, Biabmu and Arsinoe*, W. M. Flinders Petrie, p. 50.

² A. Erman, *op. cit.*, p. 156.

³ J. H. Breasted, *op. cit.*, IV, 497, 498.

⁴ IV, 476, 477.

⁵ W. M. Flinders Petrie, *The Royal Tombs of the First Dynasty*, I, p. 14.

⁶ G. A. Wainwright, *Balabish*, p. 14.

⁷ W. M. Flinders Petrie and J. E. Quibell, *Naqada and Ballas*, pp. 27, 39, 40.

all the cases known to the author it has always been a secondary smell due to chemical changes that have taken place in the fat, often being suggestive of rancid coco-nut oil and occasionally of valeric acid.¹ Very few examples of this fatty matter have been analysed, and there is no definite proof that any of the specimens were cosmetics, though in one instance this is very probable. Sometimes the fatty matter consists largely of mixed palmitic and stearic acids,^{2, 3, 4} probably representing an original animal fat. Four specimens examined have been mixed with solid material that has not been identified,^{2, 5} but which in one instance was possibly a balsam.⁴ According to Pliny,⁶ however, the Roman perfumers of his day (and possibly, therefore, the Egyptian perfumers also) thought that gum or resin added to a cosmetic fixed the perfume, and it seems possible that the solid matter referred to may have been, not a fragrant resin or gum-resin added to perfume the fat, but a non-odoriferous gum or resin used to fix a perfume obtained from some other source. Five specimens of material, all very much alike, from different compartments of a toilet box of unknown date examined by Gowland gave results from which he concluded that the material consisted of beeswax mixed with an aromatic resin and a small proportion of vegetable oil.⁷

Eight specimens of materials of unknown date, thought to be perfumes, examined by Reutter, are stated to have consisted generally of a mixture of all or most of the following named substances: storax, incense, myrrh, turpentine resins, bitumen of Judea perfumed with henna, aromatic vegetable material

¹ See Chapter IX, Oils, Fats and Waxes.

² A. Lucas, in *The Tomb of Tut-ankh-Amen*, Howard Carter, II, Appendix, II, pp. 176, 177.

³ W. M. Flinders Petrie and J. E. Quibell, *Nagada and Ballas*, p. 39.

⁴ A. C. Chapman and H. J. Plenderleith, *Examination of an Ancient Egyptian (Tut-ankh-Amen) Cosmetic*, in (a) *Journ. Chem. Soc.*, CXXIX (1926), pp. 2614-19; in (b) *The Tomb of Tut-ankh-Amen*, Howard Carter, II, Appendix, IV, pp. 206-10.

⁵ These included the specimen examined by Chapman and Plenderleith and previously by the author together with three apparently somewhat similar specimens examined by the author.

⁶ XIII, 2.

⁷ W. Gowland, *Proc. Bibl. Arch.*, XX (1898), pp. 268-9.

mixed with palm wine or the extract of certain fruits (such as cassia or tamarind) and grape wine.¹ These analyses were made on very small quantities of materials (from 0.498 gram to 2.695 grams), and the conclusions are much too definite for the chemical results obtained. Thus, that a very minute residue of black material, suggestive of bitumen and containing sulphur, was obtained from each specimen is not questioned, but the evidence is not sufficient to prove that this was bitumen of Judea.² Such a residue is not infrequent in the case of organic substances of the nature of those examined, especially when they are several thousands of years old. That bitumen was added to perfumes and in such very small proportions as the black residue represented is not only not warranted by the evidence, but is most improbable. The correctness, too, of the identification of so many different substances in the one mixture, particularly when dealing with such small quantities as were examined, needs confirmation.³

INCENSE

Since the word incense (Latin *incendere*, to burn or kindle) has the same literal meaning as the word perfume, which is the aroma given off with the smoke (*per fumum*) of any odoriferous substance when burned, incense, therefore, should be included in any description of ancient Egyptian perfumes.

That incense was employed in ancient Egypt there can be no doubt. Both incense^{4, 5} and incense burners (censers)⁶ are mentioned in the ancient records, and the offering of incense is shown in the illustrations to the Book of the Dead^{7, 8} and is one of the commonest subjects pictured in temples and

¹ L. Reutter, *Analyses des parfums égyptiens*, in *Annales du Service des Antiq. de l'Égypte*, XIII (1914), pp. 49-78.

² See p. 236.

³ See p. 260.

⁴ J. H. Breasted, *op. cit.*, v (Index), p. 134.

⁵ A. Erman, *op. cit.*, pp. 28, 33, 34, 40, 91, 102, 103, 105, 133, 209, 235, 239, 247, 287, 293.

⁶ J. H. Breasted, *op. cit.*, v (Index), p. 113.

⁷ E. A. Wallis Budge, *The Papyri of Hunefer, etc.*, Pls. 6, 7.

⁸ British Museum, *The Papyrus of Ani*, Pl. V.

tombs, and incense^{1, 2, 3} and incense burners^{4, 5, 6, 7, 8} have been found in graves.

At what date incense was first used in Egypt is uncertain, but the earliest references that can be traced are of the Fifth⁹ and Sixth¹⁰ Dynasties respectively, and an incense burner of the Fifth Dynasty⁸ has recently been discovered. The earliest certain incense of which the writer has any knowledge is from the end of the Eighteenth Dynasty, which was in the shape of small balls similar to those so frequently depicted on monuments.¹¹ Incense of the Ptolemaic period from the graves of the priests of Philae found by Reisner was also partly in the form of balls and partly as disk.³ It is recorded, too, that incense was among the foundation deposits of the tomb of Aahmes I,¹ but that this was prepared incense, such as that just mentioned, needs confirmation. It is described as being in 'pieces' and is much more likely to have been the dark brown resin, lumps of which so frequently occur in graves, particularly, but not exclusively, in those of early date and although it may have been incense, this is not certain.

The two best known and most important incense materials are frankincense and myrrh, which may now be described.

Frankincense (Olibanum)

This has been regarded from a very early period, and is still regarded, as true or genuine incense. It is a fragrant gum-resin occurring in the form of large tears, generally of a light yellowish-brown colour, though the purer varieties are almost colourless

¹ E. R. Ayrton, C. T. Currelly and A. E. P. Weigall, *Abydos*, III, p. 34.

² A. Lucas, in *The Tomb of Tut-ankh-Amen*, Howard Carter, II, Appendix, II, p. 184; III, Appendix, II, p. 181.

³ G. A. Reisner, *Arch. Survey of Nubia, Report for 1907-1908*, I, p. 85.

⁴ G. Brunton, (a) *Qau and Badari*, I, p. 35; (b) *Qau and Badari*, II, p. 6; Pl. LXXXVIII, 98 d.

⁵ G. A. Reisner, *op. cit.*, pp. 78, 82, 83, 85, 86, 87, 89, 90, 91, 92.

⁶ C. M. Firth, *Arch. Survey of Nubia, Report for 1909-1910*, p. 112; *Report for 1910-1911*, pp. 52, 53, 57, 59, 60, 61, 65, 66, 73, 78, 199.

⁷ W. M. Flinders Petrie, *Denderah*, p. 34.

⁸ H. Frankfort, *The Cemeteries of Abydos: Work of the Season 1925-26*, in *Journal of Egyptian Archaeology*, XVI (1930), p. 217.

⁹ J. H. Breasted, *op. cit.*, I, 161.

¹⁰ I, 336, 369.

or of a slight greenish tint.¹ It is translucent when fresh, but after transport (which is necessarily the condition in which it comes into commerce) it becomes covered with its own fine dust, produced by friction between the pieces, and the outside is then semi-opaque. Most other incense materials are more definitely coloured, many of them being dark yellow, dark yellowish-brown or, in a few cases, grey or black. The white incense, therefore, mentioned in the Papyrus Harris ² (Twentieth Dynasty) suggests frankincense, since this is more nearly white than any other incense material. Pliny states that whiteness was one of the features whereby a good quality of frankincense (Latin, *Thus*) might be recognized,³ and its name in Hebrew, Greek and Arabic signifies milk-white.

Frankincense is yielded by certain trees of the genus *Boswellia*, growing principally in Somaliland and southern Arabia. A variety of frankincense, however, is obtained from *Commiphora pedunculata*, which grows in the eastern Sudan near Gallabat ⁴ and also in the adjoining parts of Abyssinia. The statements in the ancient records, therefore, that incense reached Egypt from Negro tribes in the Sixth Dynasty⁵ and from Punt in the Eighteenth⁶ and Twentieth⁷ Dynasties in no way conflict with it having been frankincense, since Punt (whether Somaliland or southern Arabia) is the home of frankincense, while the Negro tribes dwelt to the south of Egypt, and a product of Punt or of the eastern Sudan might easily have passed through their country on its way to Egypt. Even the incense obtained from Retenu,⁸ Zahi⁹ and Naharin¹⁰ in the Eighteenth Dynasty may have been, at least in part, frankincense, since there would not have been any great difficulty in a product of southern Arabia reaching western Asia, though, on the other hand, this source suggests some other kind of incense material.

¹ Bertram Thomas, *Arabia Felix*, p. 122.

² J. H. Breasted, *op. cit.*, IV, 233, 239, 299, 344, 376. ³ XII, 32.

⁴ Through the courtesy of the District Commissioner, Gallabat, the author has been able to obtain some of this incense for examination. There are specimens of it in the Imperial Institute Museum, London.

⁵ J. H. Breasted, *op. cit.*, I, 336, 369. ⁶ II, 265. ⁷ IV, 130.

⁸ II, 447, 472, 473, 491, 518, 525, 616.

⁹ II, 462, 509, 510, 519.

¹⁰ II, 482.

Pliny quotes King Juba for the statement that the frankincense tree (*Thus*) grew in Carmania and Egypt, 'where' (apparently Egypt is meant) it was introduced by the Ptolemies,¹ but in another place² he says that it was ladanum (*Ladanum*) that was found originally in Carmania, and that was planted by order of the Ptolemies 'in the parts beyond Egypt.'

The trees brought by Hatshepsût's expedition from Punt, which are depicted on the walls of the queen's mortuary temple at El-Deir el-Bahari, are termed myrrh by Breasted³ and frankincense by Naville⁴ and are stated by Schoff⁵ to be *Boswellia Carteri*, the frankincense tree of Dhofar in southern Arabia. Representations of about 30 trees, or parts of trees, still exist on the walls of the temple, two forms being shown, one having luxuriant foliage and the other quite bare, but whether they are the same tree depicted differently or at different seasons of the year, or whether they are two entirely different trees there is nothing to indicate. In any case, however, they are drawn in so conventional a manner that there cannot be any certainty about their identity. Schoff takes note only of the trees with foliage (which are those usually copied) ignoring altogether those without foliage, and he says that the rich foliage cannot be meant to represent 'the bare, thorny, trifoliate, but almost leafless myrrh tree, nor the almost equally leafless varieties of Somaliland frankincense.' It is possible, however, that the trees without foliage may be intended for one of these.

Among the imports into Egypt in the Roman period on which duty was levied was frankincense⁶ (both African and Arabian), and Pliny states⁷ that this material was prepared for sale (presumably by cleaning and sorting) at Alexandria.

Lane says⁸ that the Egyptian woman of his day chewed frankincense in order to perfume their breath.

The incense from the tomb of Tut-ankhamûn already mentioned, which has been examined by the author, is possibly

¹ XII, 31.

² XII, 37.

³ J. H. Breasted, *op. cit.*, II, 264, 265, 272, 288.

⁴ E. Naville, *The Temple of Deir el-Bahari*, III, p. 12.

⁵ H. Schoff, notes to *The Periplus of the Erythraean Sea*, p. 218.

⁶ H. Schoff, *op. cit.*, p. 289.

⁷ XII, 32.

⁸ E. W. Lane, *op. cit.*, p. 194.

frankincense. It is of a light yellowish-brown colour, brittle, slightly resinous-looking, burns with a smoky flame, giving off a pleasant aromatic odour and has a solubility of approximately 80 per cent in alcohol and 20 per cent in water and is therefore a gum-resin and so cannot be ladanum, Mecca balsam or storax, and the colour is not that of myrrh, bdellium or galbanum, and altogether it is very suggestive of frankincense that has been powdered and made into balls.¹

Myrrh

Myrrh, like frankincense, is a fragrant gum-resin and is obtained from the same countries as frankincense, namely, Somaliland and southern Arabia. It is derived from various species of *Balsamodendron* and *Commiphora*, and occurs in the form of yellowish-red masses of agglutinated tears, often covered with its own fine dust; it is never white or green and so cannot be either the white² or green³ incense referred to in the ancient records. In Breasted's translation of these records it is stated that myrrh was obtained from Punt (Fifth,⁴ Eleventh,⁵ Eighteenth,⁶ Twentieth⁷ and Twenty-fifth⁸ Dynasties) and from Genebteyew⁹ (Eighteenth Dynasty), which is in agreement with its known origin. Even the receipt of myrrh from Retenu¹⁰ in western Asia (Eighteenth Dynasty) is not impossible, since it might readily have reached Retenu from Arabia.

Theophrastus and Pliny have already been quoted¹¹ for the statements that myrrh entered into the composition of certain Egyptian unguents, and Plutarch mentions the use of myrrh as incense in Egypt.¹²

Myrrh has been identified by Reutter in ancient Egyptian perfumes¹³ (undated), and specimens of gum-resin from certain

¹ A. Lucas, in *The Tomb of Tut-ankh-Amen*, Howard Carter, III, Appendix II, pp. 181-2.

² J. H. Breasted, *op. cit.*, IV, 233, 239, 299, 344, 376.

³ II, 572.

⁴ I, 161.

⁵ I, 429.

⁶ II, 265, 274, 276, 277, 321, 486.

⁷ IV, 130, 210, 407.

⁸ IV, 929.

⁹ II, 474.

¹⁰ II, 491.

¹¹ See pp. 86-7.

¹² *Isis and Osiris*, French trans., M. Meunier, p. 164.

¹³ L. Reutter, *Analyses des parfums égyptiens*, in *Annales du Service*, XIII (1914), pp. 49-78.

royal and priestly mummies of the Eighteenth, Nineteenth, Twentieth and Twenty-first Dynasties respectively examined by the author were probably myrrh.¹

Satisfactory incense materials other than frankincense and myrrh are very few and must have been still fewer in ancient Egypt, since such substances as benzoin and camphor from the Far East and, in the earlier periods, the products of India were probably not then available. Speculation, however, as to what might have been employed is of little value and may be misleading, and only those materials will be mentioned for the use of which in Egypt there is some probability, and these are limited to galbanum, ladanum, and storax, which may now be described.

Galbanum

This is a fragrant gum-resin generally occurring in masses of agglomerated tears and is of a light brownish-yellow to a dark brown colour, with often a greenish tint ; it has a greasy appearance and, though usually hard, it may occasionally be of semi-solid consistency ; it is a native of Persia and a product of various species of the umbelliferous plant *Peucedanum*, of which *P. galbaniflorum* is the most important. This is the only green incense material known to the author, except that frankincense is green when freshly gathered² and even as found in commerce it may occasionally have a slight greenish tint. As there would not have been any difficulty in galbanum reaching Egypt from Persia in the Eighteenth Dynasty, this may well have been the green incense mentioned in the ancient records.³ According to Pliny,⁴ galbanum was one of the constituents of the Mendesian unguent, and it is mentioned in the Bible as entering into the composition of Jewish incense.⁵ There is no record of galbanum having been found in ancient Egyptian graves.

¹ A. Lucas, *Preservative Materials used by the Ancient Egyptians in Embalming*, pp. 26-9.

² Bertram Thomas, *Arabia Felix*, p. 122.

³ J. H. Breasted, *op. cit.*, II, 572.

⁴ XIII, 2.

⁵ *Exodus*, xxx, 34 (Revised Version).

Ladanum

This, unlike the other incense materials described, is a true resin and not a gum-resin; it occurs in dark brown or black masses, which are often viscid or easily softened by handling, and is obtained from various species of *Cistus* that grow in Asia Minor, Crete, Cyprus, Greece, Palestine, Spain and other parts of the Mediterranean region, though not at the present time in Egypt. Pliny states¹ that the Ptolemies introduced ladanum into 'the parts beyond Egypt,' the meaning of which is obscure.²

Newberry has recently suggested³ that the ancient Egyptians were acquainted with ladanum as early as the First Dynasty. From purely theoretical considerations this is only what might be expected, since, even if ladanum were not an Egyptian product, it was abundant in countries bordering the Mediterranean with which Egypt had intercourse and from which it might easily have been obtained. No positive evidence, however, can be found for this early use. The earliest literary references known to the author for the use of ladanum in Egypt are in the Bible, where it is stated that certain merchants carried ladanum into Egypt from Gilead⁴ and that Jacob sent ladanum to Egypt as a present to his son Joseph.⁵ The date of this record is probably not earlier than the tenth century B.C. and possibly as late as the eighth century B.C. Incidentally it may be noted that the sending of ladanum from Palestine to Egypt suggests that ladanum at that time was either not a product of Egypt or that it was not very plentiful. The next literary reference in date order that can be traced is the one already quoted from Pliny in the first century A.D. In modern times Lane states that it was customary for the Egyptian women of his day to chew ladanum to perfume their breath.⁶

So far as is known, the only instance of ladanum having been found in connexion with ancient Egypt is a specimen of Coptic incense of the seventh century from Faras near Wâdi Halfa,

¹ XII, 37.

² See p. 93.

³ P. E. Newberry, in *Journal of Egyptian Archaeology*, xv (1929), p. 94.

⁴ *Genesis*, xxxvii, 25 (Revised Version).

⁵ *Genesis*, xliii, 11 (Revised Version).

⁶ E. W. Lane, *op. cit.*, p. 194.

which was examined by the author and the results published some years ago.¹ This was a fragrant, black resin containing 31 per cent of mineral matter and is probably ladanum.

Storax

Storax (*Styrax*) is a balsam obtained from the tree *Liquidamber orientalis*, belonging to the natural order *Hamamelideæ*, indigenous to Asia Minor. It is a turbid, viscid greyish liquid having an odour like benzoin and belongs to the same class of bodies, the distinguishing feature of which is that they contain either cinnamic or benzoic acid, storax containing the former. At one time, however, the name storax was applied to the solid resin obtained from *Styrax officinalis*, which somewhat resembles benzoin. Reutter has identified storax in Egyptian mummy material² and in ancient Egyptian perfumes,³ both unfortunately undated. There does not appear to be any evidence that 'gum-styrax, modern storax, was taken from trees in upper Egypt,' as stated by Rostovtzeff, and the word translated by him as *styrax* is rendered by Edgar as 'vegetable juice.'⁴

Miscellaneous Incense Materials

Specimens of various miscellaneous materials of ancient Egyptian origin submitted as incense have been examined by the author from time to time and may now be described. One of these was Coptic incense of the same date and from the same place as the ladanum already mentioned. This second specimen, however, was very different; it was in irregular-shaped pieces of a dark reddish-brown colour, translucent when freshly fractured, very resinous-looking and possessed a fragrant smell. On analysis it proved to be a true resin, as distinguished from a gum-resin, and therefore could not be frankincense, myrrh, galbanum or storax, and its colour was not that of ladanum; it was not identified.¹ A specimen of material found

¹ A. Lucas, *Preservative Materials used by the Ancient Egyptians in Embalming*, pp. 31-2.

² L. Reutter, *De l'embaumement avant et après Jésus-Christ*, pp. 49, 59.

³ L. Reutter, *Analyses des parfums égyptiens*, in *Annales du Service*, XIII (1914), pp. 49-78.

⁴ M. Rostovtzeff, *A Large Estate in Egypt in the Third Century, B.C.*, p. 178.

by Legrain at Karnak was dull and opaque in appearance, and on analysis proved to be a true resin mixed with 76 per cent of limestone dust. Although described by the finder as incense, it is suggested that it was a cementing material similar to that discovered at Karnak a few years later by Pillet.¹

A mixture of resin (or gum-resin) and natron was found in the tomb of Tut-ankhamûn, which may have been incense, natron being sometimes used in incense.² The resin (or gum-resin, there was too little of the specimen available for this point to be determined) is in the form of very small tears and rods, the latter being 2 to 5 mm. long and 0.5 mm. in diameter; it is white on the outside from adhering natron and its own fine dust, but light yellowish-brown in the interior; it is largely, though not entirely, soluble in alcohol: it has not been identified, but it is certainly not myrrh and the appearance is not that of frankincense.³

That frankincense occurs in the Sudan has already been stated, but in addition there are also other materials that might be employed as incense, though whether they have been so used is unknown. The author has examined two of these, one *Gafal* resin stated to be obtained from *Balsamodendron africanum* and the other the product of *Gardenia Thunbergia*. The *Gafal* resin was in the shape of irregular-shaped masses, yellowish, light brown or dark brown in colour and generally translucent and very resinous-looking. The *Gardenia Thunbergia* product was also in irregular lumps, but very different in appearance from the *Gafal* resin; it varied in colour from a light yellowish-brown to black and was entirely opaque. Both materials are fragrant gum-resins and seem very suitable for incense purposes.

As already mentioned, resin is a very common material in ancient Egyptian graves of all periods, being a marked feature of Badarian and predynastic burials long before mummification was practised and also of early dynastic burials in cases where

¹ M. Pillet, *Annales du Service*, xxiv (1924), pp. 64-5.

² (a) British Museum, *Introductory Guide to the Egyptian Collections*, 1930, p. 5;
(b) E. A. Wallis Budge, *The Literature of the Ancient Egyptians*, 1914, pp. 14, 38, 218.

³ A. Lucas, in *The Tomb of Tut-ankh-Amen*, Howard Carter, III, Appendix II, p. 181.

the body had not been mummified, either because the practice was not yet known, or because it had not become general.

This resin is always a true resin, as distinguished from gum-resins such as frankincense and myrrh, which latter are products of countries that are farther south and hotter than Egypt, whereas most true resins, and probably all those under discussion, are either from coniferous trees (cedars, pines, firs, spruces, cypresses and junipers) or from species of *Pistacia* (chiefly *P. terebinthus*) that grow in countries more northerly and colder than Egypt and, considering the early connexions of Egypt with western Asia, where such trees are plentiful, this would seem a likely source from which these resins might have been obtained.

These resins, many of which are very similar in appearance, are usually without smell, though occasional specimens are fragrant: they are generally opaque and of a dull brown colour on the outside, but bright and resinous-looking in the interior: they give similar results on analysis and are probably largely, though not entirely, of one kind, the botanical source of which it has not been possible to determine. As these resins are of a date before mummification and also before the use of resin for varnish or as an adhesive or for making into personal ornaments and other objects,¹ except occasional small beads which have been found from predynastic times,² the most likely use seems to have been as incense, more particularly as there is no evidence that frankincense and myrrh were known before the dynastic period. As a rule, however, the smell produced when this resin is burned is not fragrant according to modern ideas, being very like burning varnish, though occasionally specimens have been examined that are aromatic. If incense, this was the forerunner of the more sweet-smelling and probably much more rare and expensive frankincense and myrrh and, if not incense, then the almost entire absence in graves of one of the most commonly employed materials in the religion and magic of ancient Egypt remains unexplained.

¹ See p. 337, where a list is given of resin objects found in the tomb of Tut-ankhamûn.

² E. R. Ayrton and W. L. S. Loat, *The Predynastic Cemetery of El Mahasna*, pp. 11, 17, 27, 31.

Possibly, too, even after frankincense and myrrh became known their use was restricted to special occasions on account of their rarity and price, a more easily obtained and cheaper material being employed for ordinary purposes and by the poorer people, which would explain the occurrence of this brown resin in the graves of all periods and of all ranks.

CHAPTER V

FAIENCE AND GLASS

FAIENCE

Although the term faience may not be strictly correct etymologically and although 'glazed siliceous ware,' suggested by Burton,¹ is more in accordance with its composition, it is proposed to retain the conventional name generally applied to this material. The term 'glazed pottery,' often used, is entirely wrong, pottery being ware made from clay, moulded into shape while wet and then hardened by being baked.

Faience is as old as predynastic times and by the early dynastic period it had reached a high state of development, being used for example at the beginning of the Third Dynasty in the form of small blue tiles for covering walls, as in the step pyramid at Saqqâra and in the neighbouring large tomb: its production continued as late as the Roman period. It was employed for making beads, necklace pendants, rings, amulets, tiles, bowls, vases, animal figures, *shawbti* figures and many other objects.

When a broken surface of faience is examined, the material is seen to consist of at least two, and sometimes of three, different layers, always an inner core with an outer coating of coloured vitreous glaze, but occasionally also an additional thin layer between the core and the glaze, which when present is usually very marked on account of the difference in colour and density between it and the core.

Body Material.

The body or core consists of gritty material, generally very fine, but occasionally comparatively coarse (the coarsest examined

¹ W. Burton, *Ancient Egyptian Ceramics*, in *Journal, Royal Society of Arts*, LX (1912), p. 596.

being of Nineteenth or Twentieth Dynasty date), frequently white, but almost as frequently tinted slightly blue, green, light brown, or grey, the blue and green being almost certainly due to a small amount of glaze mixed with the body substance.¹ The white, brown and grey are always friable and sometimes very friable, but the blue and green are less friable. One feature always present is a large number of tiny air-holes throughout the mass.

When examined microscopically, the better quality of body material is found to consist of very fine clean, sharp, angular grains of quartz, without any visible mixture of clay or other ingredient and it has all the appearance of having been artificially powdered, which is believed to be the case. The coarser material mentioned is also quartz, but coloured brown and less finely powdered.

Only very few chemical analyses of faience can be traced and of these many are unsatisfactory, either because no particulars of the kind or date of the specimens analysed are given, or because the results are so abnormal that either the specimens were not representative or the glaze was not separated from the body before analysis. Five analyses only will be quoted,² three by Burton³ and two by the author. In Burton's results the proportion of silica in the body substance varies from 94.0 per cent to 94.2 per cent, while analyses by the author show 94.7 per cent for a specimen of the coarse material of Nineteenth or Twentieth Dynasty date mentioned and 99.6 per cent for a specially selected white material of the Nineteenth Dynasty. The ingredients other than silica will be considered later.

From its appearance and chemical composition, the body material undoubtedly consists of artificially powdered quartz, but what particular form of quartz was employed it is impossible to prove, and different forms may have been used at different times and in different places, that special variety being chosen

¹ See p. 113.

² Additional analyses may be found in (a) J. L. I. Artigas, *Les pastes ceramiques i els esmalts blaus de l'antic Egipte*, Barcelona, 1922, and (b) D. Fouquet, *Contributions à l'étude de la céramique orientale*, in *Mémoire de l'Inst. Egypt*, IV (1901), pp. 1-164.

³ W. Burton, *op. cit.*, p. 594.

that was available locally. A mistake frequently made in these matters is to assume that because there is evidence of the use of a particular material for a certain purpose at one period or in one locality, therefore, the same material was employed at other periods or in other localities, though this is not necessarily so.

For the ordinary white material and that originally white until it became tinted with the coloured glaze, only three origins seem possible namely, quartz rock ; white quartz pebbles or white quartz sand. Quartz rock, which occurs as veins in the igneous rocks of the eastern desert and also at Aswan, would have been very suitable and from it similar material has been made, but the eastern desert sources are not very accessible and the rock would have taken considerable labour to quarry and prepare. It should not be forgotten, however, that during the early dynastic period quartz rock was being used occasionally for making small vases and other objects. From white quartz pebbles a very satisfactory imitation of the ancient material has been prepared, and such pebbles are found plentifully on the desert and in the *wâdis* (valleys) in a large number of places and, therefore, would have been easily procured and cheap, and these seem the most likely general source. Also, occasional particles of the body substance of faience, when examined microscopically, are seen to be stained brown with oxide of iron, and similar staining exists on quartz pebbles and consequently on some of the particles of the powder made from them but not usually on quartz rock. Quartz sand, of the purity and whiteness of the faience body material, is very rare and no such sand could be found in the collection of sands in the Geological Museum, the whiteness of the best quality,¹ even when finely ground, being much less than that of the better quality faience body. Hume, however, states ² that ' At Aswan there are also sands of pure snowy-white silica, mixed with occasional grains of felspar and carbonate of lime . . . ' For the comparatively coarse brown material mentioned, coarsely powdered sand or sandstone seems likely to have been employed.

¹ Mr. O. H. Little, Director of the Geological Survey, kindly supplied the author with specimens for experimental purposes.

² W. F. Hume, *Geology of Egypt*, I, p. 59.

Extra Layer.

The only reference to the additional layer sometimes present in faience is Reisner's description of it as found in the faience made by the Twelfth Dynasty Egyptian colony who settled at Kerma in the Sudan,¹ in which it is termed both 'size' and 'paste' and described as being firm, hard and varying in colour on differently coloured body materials, being white and like plaster of Paris on a light coloured core; white or yellow on a yellowish drab core and white or dark grey on a dark grey core.

Any generalization with respect to the prevalence of this special layer would be dangerous without the examination of more specimens of faience of different kinds and dates than it usually falls to the lot of any one individual to handle, more especially as it is only with broken objects (which generally are not to be found in museums) that its presence or absence can be detected, but the author's experience may be given. In addition to the occurrence of this layer in the Twelfth Dynasty faience from Kerma described by Reisner, it was found by him in faience of the same period from Shalfak (Sarras) also in the Sudan, specimens of both of which he kindly allowed the author to examine and analyse: it is not present in the small blue tiles of the Third Dynasty from Saqqâra; nor did it occur in several specimens of Twelfth Dynasty faience from Lisht nor in a specimen of the same date from El-Bersha and only in one specimen (a thick flat piece from El Deir el-Bahari, probably part of a tile, with a beautiful blue glaze on one side only) out of several hundreds examined from the Eighteenth Dynasty, though it was present in several undated specimens which were possibly from this Dynasty: it was rarely present in the late material, only a few examples having been found out of many hundreds of specimens examined, these being (a) a comparatively small number of pieces of the coarse brown body material of Nineteenth or Twentieth Dynasty date collected by Mahmud Hamza at Qantîr,² several of which the finder kindly

¹ G. A. Reisner, *Excavations at Kerma*, IV-V, pp. 134-75.

² M. Hamza, *Excavations of the Department of Antiquities at Qantîr (Faqûs District)*, in *Annales du Service*, xxx (1930), pp. 31-68.

gave to the author for detailed examination, and (b) one lot of *shawbti* figures of Twenty-sixth Dynasty date.

This extra layer, in those instances in which it has been measured, which, however, seem typical of the rest, varied in thickness from about 0.5 mm. to 2.5 mm. : in a Kerma specimen it was white on a light grey body and, as Reisner states, very like plaster of Paris in appearance : in a Shalfak specimen it was white on a light blue body : in the Eighteenth Dynasty tile mentioned it was white on a faintly blue-tinted body : on the Qantîr specimens it was white on a brown body and on the Twenty-sixth Dynasty specimens it was white on a dark grey body, and in every instance in which it has been examined the special layer has consisted of very finely powdered quartz, always more finely ground and more compact than the body substance. There can be little doubt, as pointed out by Reisner, that the special layer was employed for the purpose of enhancing or modifying the colour of the glaze, thus when a coloured body material would have lessened or spoiled the full brilliance of a blue glaze, a thin layer of perfectly white material was interposed between the two : sometimes when a green glaze was required a yellow layer was used underneath the blue to give it the necessary greenish tint, and in one of the specimens from Qantîr a white layer was used under parts only of a blue glazed surface in order to give to those parts a lighter colour, thus forming a light blue pattern on a dark blue ground.

Glaze

The glaze on faience has been described as 'vitreous,' which is correct, but ambiguous, as this may mean either that it is of the nature of glass or merely that it resembles glass in appearance. In this case, however, the former is intended, as the glaze consists of a thin coating of true glass. The author has made a number of qualitative analyses of this glaze and there can be no doubt that it is actually glass, but only one quantitative analysis can be traced, which is that of a specimen taken from a fragment of blue faience of Graeco-Roman date found by the author at Dimai in the Fayûm and kindly analysed for him by Mr. J. Clifford.¹ From the results of the analysis it is

¹ For details of analysis, see p. 418.

evident that this particular specimen is not only glass, but that it is of similar composition to the ancient glass and that the colour, like that of much of the blue of glass, is due to a copper compound. The large amount of potassium oxide¹ and the small amount of sodium oxide¹ present show that the alkali employed in this instance was not natron, but plant ashes, though natron was undoubtedly largely employed for glass making in ancient Egypt, as analysis proves and as the remains of glass factories in the Wâdi Natrûn also show.

Vitreous glazes of the kind under discussion are only satisfactory on highly siliceous material, such as the body substance of faience, since they will not adhere to pottery (baked clay) unless a layer of siliceous material is put on before the glaze. For pottery, the glaze is either a lead glaze or a salt glaze, both of which were used in Egypt after the Arab conquest,² but so far as can be ascertained, not before that time.

The only difference between the ancient glaze and the ancient glass is in the manner in which they were employed, glaze being simply glass applied to the surface of another material.

The glaze of faience being glass, it is to be expected, therefore, that it should be coloured in the same manner as glass and, so far as the colours have been investigated (which unfortunately has only been to a small extent), this is true. The blue, as already stated, is generally due to a copper compound: the green, when original, is also usually due to a copper compound, though sometimes apparently, as seems indicated by it occasionally turning brown, it is due to an iron compound; frequently, however, the green is a secondary colour produced by some chemical change in the blue, which often becomes green and then fades to white, especially when exposed to damp³; occa-

¹ Although the potassium and sodium are shown as oxides in the analysis (which is the usual manner of reporting them), this does not mean that they were present in the glaze in that form, which is not so, as they occurred as silicates.

² Two specimens of glaze taken from Arab ware found at Fustât analysed in the author's laboratory by Mr. J. Clifford proved to be a lead glaze and a salt glaze respectively; see p. 418.

³ Many examples of this change are known, especially in the case of libation and other vases, some of which, though largely green, still show a few blue patches.

sionally, too, as already described, a blue colour was made to appear green by being laid on a yellow: the violet is due to a manganese compound.

A vitreous glaze was not only used for faience, where it was applied to powdered quartz, but it was also used on small objects of solid quartz and rock crystal and also on steatite. Petrie states¹ that 'After the glazing on a sandy base, glazing on stone began in the second civilization,' but since this was written beads of glazed stone, probably steatite, have been discovered by Brunton from the Badarian civilization,² from which period faience is unknown and hence glazing on stone would seem to have ante-dated glazing on quartz frit, the latter not having been found before predynastic times.^{3, 4} Glaze was used in Egypt before glass.

Shaping

The next question to be considered is how such a material as powdered quartz was shaped. Burton's suggestion⁵ that faience objects were carved out of sandstone cannot be accepted for many reasons, chiefly because the material has not the naturally rounded grains of sandstone, but sharp angular grains that prove it to be artificially prepared and because no such fine white sandstone is known, but also because the body material of faience is usually so friable that carving would have been impossible. The question, however, has been partly settled by the discovery of very large numbers of red pottery moulds, though none earlier than the Eighteenth Dynasty. Petrie 'brought nearly five thousand from Tell el Amarna after rejecting large quantities of the commonest'⁶ and Mahmud Hamza, assistant keeper of the Cairo Museum, collected 'about ten thousand' of about Nineteenth or Twentieth Dynasty date from Qantâr, 'most of which still bear traces of the colour

¹ W. M. Flinders Petrie, *Prehistoric Egypt*, p. 42.

² G. Brunton and G. Caton-Thompson, *The Badarian Civilisation*, pp. 27, 39, 57.

³ W. M. Flinders Petrie, *op. cit.*, pp. 42-3.

⁴ G. Brunton and G. Caton-Thompson, *op. cit.*, pp. 56-7.

⁵ W. Burton, *op. cit.*, pp. 594-9.

⁶ W. M. Flinders Petrie, *Tell el Amarna*, p. 30.

and the paste used in the process of manufacture'¹: 'At Naukratis hundreds were found for making scarabs for the Greek trade'²: 'Such moulds have been found in many other places, Memphis, Thebes, Gurob, etc.'³ Writing of these moulds, Petrie says² 'They sometimes contain the remains of the siliceous paste with which they were choked when they were thrown away.' Most of the moulds referred to are for small objects, but there are also larger ones for figures, including *shawbti* figures, and other objects. The moulds in the Cairo Museum for making *shawbti* figures, though unbroken, are for the upper part of the body only down to about the knees: all the moulds found have been open, that is they are for one side (the front) of the object only. Petrie states⁴ that the 'paste was roughly moulded into form and when dry it was graved with a point to give detail' and also that large objects were made in sections, which were joined together with some of the same paste before glazing. Faience objects, however, were not always moulded, as Reisner states⁵ that the thin bowls, the larger jars and some of the other jars from the Middle Kingdom Egyptian colony at Kerma in the Sudan had been turned on the wheel; that most of the smaller jars had been made on a core; that a few poor jars showed traces of gouging as if they had been formed solid and dug out while still moist; that figures and amulets had been modelled by hand and finished with a point or blade, and that none of the objects had been made in moulds; and the author would venture to suggest that bowls and vases, especially such as the libation vases of 'teapot' form, could only have been made by pottery methods and not by moulding, though the spouts and lids may have been moulded.

Adhesive

A most important point in connexion with faience is how the body material, which when dry is entirely without any coherence whatever, was held together while being shaped and glazed and

¹ M. Hamza, *op. cit.*, p. 42.

² W. M. Flinders Petrie, *The Arts and Crafts of Ancient Egypt*, pp. 118-19.

³ W. M. Flinders Petrie, *Tell el Amarna*, p. 30.

⁴ W. M. Flinders Petrie, *The Arts and Crafts of Ancient Egypt*, pp. 115-16.

⁵ G. A. Reisner, *Kerma*, IV-V, p. 137.

how the special layer, when present, was applied. That some binding substance was used in small amount seems probable. This is frequently stated to have been clay, though alkalis, milk of lime and organic materials, such as oil, fat, gum or glue have all been suggested, to which the author would add glaze, which suggestions may now be examined.

Clay. With respect to clay Burton says ¹ 'After having tried many mixtures of the kind indicated by these analyses, I have been forced to the conclusion that the small amount of clay indicated by the percentage of alumina found ² would be entirely insufficient to give a material that could be shaped by pottery methods . . .' and he says ³ of an Eighteenth Dynasty *shawbti* figure he examined that there was 'no trace of any clay substance.' The alumina found on analysis, however, is not necessarily present as clay (aluminium silicate), but may occur in some other form, such for example as oxide, and the microscopical examination does not indicate the presence of any extraneous or added material of any kind, the ingredients other than quartz that are disclosed by chemical analysis being either chiefly natural impurities in the quartz (such as the oxide of iron mentioned) or accidental impurities adhering to the quartz or picked up during the grinding and manipulation.

Alkalis. The only alkalis known to the ancient Egyptians were (a) impure potassium carbonate in the form of plant ashes and (b) sodium carbonate and bicarbonate in the form of natron, and any simple addition of either of these would have been useless, as they are not adhesives. As, however, both potassium carbonate and sodium carbonate will combine chemically with quartz when strongly heated, forming potassium or sodium silicate respectively, a large number of experiments were made with dry powdered natron and quartz powder obtained by grinding quartz pebbles very finely. The mixture was pressed with the fingers into small ancient red pottery moulds and heated in a small electric muffle furnace, the result being a coherent mass having varying degrees of hardness depending upon the

¹ W. Burton, *op. cit.*, p. 595.

² The amount of alumina present in Burton's analyses varied from 0.6 to 1.9 per cent.

³ W. Burton, *op. cit.*, p. 596.

proportion of natron present. With 2 per cent of natron the mass was so friable that it could not be removed from the mould without breaking; with 5 per cent of natron it approximated closely in friability to much of the ancient white body substance; with 10 per cent of natron it was slightly harder than the ordinary faience and with 20 per cent of natron it was much harder. These experiments were repeated several times with substantially the same results. Natron, therefore, in the form of dry powder, added in the proportion of from about 5 per cent to about 10 per cent, may have been the agent employed anciently to bind the quartz together while it was being moulded and glazed.

But, it may be asked, if such a substantial proportion of natron were used, why is it that it has hitherto escaped notice and why is it not disclosed by chemical analysis? The reasons are briefly as follows: Natron consists essentially of sodium carbonate, sodium bicarbonate and chemically combined water (water of crystallization), but it also always contains both sodium chloride (common salt) and sodium sulphate as impurities and sometimes in considerable amount, the particular natron employed for many of the experiments containing 24 per cent of the former and 10 per cent of the latter. When natron is strongly heated in contact with quartz, the sodium chloride disappears by volatilization¹; the sodium bicarbonate loses carbon dioxide and water and becomes converted into sodium carbonate; the sodium carbonate (both that originally present and that formed from the bicarbonate) combines with some of the quartz forming sodium silicate and carbon dioxide; which latter escapes, together with the water of crystallization and any moisture present. The total loss (sodium chloride: carbon dioxide; combined water and moisture, the escape of which would account for the air holes in the finished product) would generally amount to more than 70 per cent of the weight of natron used, thus for every ten grams of natron (if 10 per cent were used) not more

¹ In the absence of a reducing agent, such as carbon (which is specially added in modern glass manufacture), heat and silica alone cannot decompose sodium sulphate, which, therefore, remains. Occasionally sodium sulphate has been found by the author in the decomposing glaze of 'faience,' and this has probably originated in the natron used for making the glaze.

than about three grams of material would be left combined with every 100 grams of quartz and, considering the very minute amount of the specimen taken for microscopical examination, it is no wonder that such a small proportion of sodium silicate (which is a substance without colour or other conspicuous characteristic) should escape notice, and in the chemical analysis the silica part of the sodium silicate is derived from and is identical with the quartz and can only be reported with it and, although a small proportion of sodium is generally found, it can only be reported as 'sodium oxide' or 'alkali.'

But, although dry natron might have been employed for objects that were moulded, it certainly could not have been used for objects that were shaped by hand, and experiments, therefore, were made with natron solution and it was found that, on account of the extreme fineness of the quartz powder, any solution, even plain water, conferred on it a slight degree of plasticity and that with a strong natron solution the plasticity was sufficient for the quartz to be made into a paste that with care might be fashioned into rough shapes, which on partial drying could be further shaped with a pointed instrument, and that when quite dry could be handled without damage and hence could be baked and glazed. Whether such a paste could be turned on a potter's wheel has not been tried, but it seems quite possible that it could be manipulated with the primitive wheels, or rather turn-tables, used in ancient Egypt.

Lime. The use of milk of lime¹ has been suggested by Beck, who says,² 'The core appears to be very nearly pure silica, has much the chemical composition of a silica brick, and is probably made in somewhat the same way. If powdered quartz crystals were mixed with about 2 per cent of lime¹ and then heated in a furnace, a vitreous mixture would be formed which would cement the whole together, and it has been found in practice that this amount of lime,¹ when added in the form of milk of lime,¹ is sufficient to bind the dried material

¹ Mr. Beck has informed the author that carbonate of lime and not quick-lime or slaked lime is meant.

² H. C. Beck, *Report on Qau and Badari Beads*, in *Qau and Badari II* (G. Brunton), pp. 24-5. See also Appendix I, by H. C. Beck, in *The Zimbabwe Culture*, G. Caton-Thompson.

together before firing . . . The analysis is practically the same as that given by Burton for Egyptian faience. I have examined some . . . sections of silica brick, and find that under certain conditions the quartz breaks and fuses in a manner extraordinarily similar to the faience. . . . One of the difficulties of this suggestion is that the lime and quartz would probably not fuse at a lower temperature than about $1,100^{\circ}$ centigrade.'

In addition to the difficulty to which Beck draws attention, namely, the very high temperature required to fuse a mixture of carbonate of lime and quartz, there are other difficulties, for example, in the case of lime-sand bricks it is lime not carbonate of lime that is used, and, as already explained, there is no evidence that the ancient Egyptians knew of lime before the Ptolemaic period;¹ also when a lime-sand brick is examined it is seen that each grain of sand is surrounded by a thin film of lime, or silicate of lime, which is not the case with faience, the appearance of the two being totally different, and for the manufacture of lime-sand bricks a very considerable pressure (about 100-150 tons per brick) is necessary for the moulding, after which a treatment with steam under pressure (about 125 pounds pressure) in an autoclave is required, all of which would have been impossible in ancient Egypt.

A number of experiments were made by the author, using both milk of lime (i.e. slaked lime and water) and also powdered quicklime in various proportions, ranging from 2 per cent to 50 per cent, the mixture being heated to the highest temperature available, about $1,000^{\circ}$ C. and in no case was there any cohesion or fusion, the mixture remaining in the original condition of a powder, though doubtless there would have been fusion at a still higher temperature.

Organic Materials. With respect to the use of organic materials, such as fat, oil, gum or glue, the author thought at one time that there was possibly a small amount of evidence for their use, though this 'was too slight to be in any way conclusive.'² Thus, in several instances, specimens of faience examined have shown a few small particles of black organic matter distributed throughout the mass that conceivably might have been the remains of some such adhesive and in a large number of specimens

¹ See p. 73.

² A. Lucas, *Ancient Egyptian Materials*, pp. 34-5.

from the Twenty-sixth Dynasty, constituting one lot of *shawbti* figures, the body material showed an inner grey-coloured core surrounded by a zone of white. Under the microscope the grey core was seen to contain numbers of black particles, which were probably charred organic matter and, on strongly heating, this core became definitely lighter coloured, though not white. It was suggested therefore that some organic adhesive might have been used for binding the quartz together and that the dark centre was due to this not having been completely burned away, but it is equally possible that the white outer layer was intentional and was the 'special' layer already described, put on in order to prevent the dark grey of the body from affecting the colour of the glaze, and that the grey may be due to organic matter, present as an impurity either in the quartz or in the natron, having been charred but not burned out.

In order to test the value of organic materials as binders for quartz powder, a number of experiments were made with gum and oil, both of which formed a paste with the quartz that could be moulded and modelled. The objects made with gum could not be removed from the moulds either when dried, when they were firmly cemented in, or after firing, as they were then too friable, and if modelled and fired, the gum burned out leaving the objects so fragile that it was impossible to handle them for glazing without breaking. The objects made with oil naturally did not dry and therefore could not be removed from the moulds and, whether moulded or modelled, after firing they were like those made with gum, so fragile that they could not be handled.

Glaze. In those instances in which the body material of faience is tinted slightly blue or green, this colour, which at first sight appears to have been caused by some of the glaze having penetrated the quartz of the body, is believed to be due to a small amount of glaze having been deliberately mixed with the quartz as a binder. Against the accidental penetration of the glaze into the body material there are several objections, namely, first, that the glaze would probably have been too viscous to penetrate and, second, that if there had been penetration, it would have been greatest near the surface and would have progressively diminished towards the centre, whereas the

colour is uniform throughout. It seems much more likely that a little glaze, probably in powdered form, was mixed with the quartz and that the mixture was moulded and fired, when the glaze would have fused and bound the quartz together. Another possibility, however, is that specimens of faience, accidentally damaged during making or imperfect from other causes, were ground up, body and glaze together, and re-used. When examined microscopically, tiny particles of blue or green material, almost certainly glaze, are seen mixed with the quartz.

Summary. Of the various materials that have been suggested as adhesives for the quartz powder of the body substance of faience, so as to enable it to be shaped and glazed, the use of clay can be disproved: lime is unlikely: organic materials are unsatisfactory and proved impossible in the experiments made and only natron (either dry or as a solution) and powdered glaze seem at all probable and with the former good imitations of the ancient faience have been made.

With respect to the method of applying the 'special' layer sometimes present, which consists of exceedingly finely ground quartz powder, it was found by experiment that a good, strongly adherent white layer of any thickness desired could be made by using a mixture of very fine quartz powder and natron solution, drying and firing. On account of the porosity of the body substance the mixture must not be too viscous (otherwise owing to abstraction of water by the quartz it becomes too thick to be laid on evenly) and if carefully poured on it forms a uniform layer with a flat surface, which when dried and fired becomes strongly adherent. Another method, proved by experiment to be possible though not very satisfactory, is to mix the quartz powder with a solution of gum, apply it wet and then dry it, when it adheres well, but when the glaze is fired the gum burns out leaving the special layer more friable than it is in faience.

The manner in which the glaze was applied anciently has not been determined, but dipping the object in the fused glaze and firing seems the most probable for small articles, but improbable for large articles, except possibly at a late date, on account of the large-sized crucible and the considerable volume of molten

glaze that would have been required, which probably were not possible of attainment at the dates when faience was first made. An alternative would have been to have poured the molten glaze on the object and then fired it in such a manner as to obtain a uniform coating. Another alternative, which the author has tried and found possible, would have been to have painted on the object a coating of powdered glaze mixed with gum solution and to have fired this, when the gum would have burned out leaving a uniformly glazed surface. A variant of this would have been to have painted on the object a mixture, in finely powdered form, of the ingredients used to make the glaze, thus forming the glaze *in situ*. The remains of two faience works were discovered by Petrie at El-Amârna¹ and the remains of a very extensive one at Qantîr by Mahmud Hamza.²

GLASS

Although the chemical composition of ancient Egyptian glass is essentially the same as that of the ancient glaze, there is the difference between them that has already been mentioned, namely, the manner in which they were used, glaze always being applied to the surface of an object, whereas glass was employed independently, and, although with glass there was sometimes a temporary core, it was one to which the material was not intended to adhere and which was removed when the object was finished. This distinction is a most convenient one that should be maintained, as the use of glass on a large scale, as distinct from glaze, marks a definite epoch.

Origin and Date

In view of the very close connexion between glaze and glass, it seems highly probable that glass was not a separate discovery apart from glaze, and the method of making glass vases in Egypt by winding rods of semi-molten glass round a sandy clay core and afterwards heating the object until the rods coalesced, the core being subsequently removed, which is strongly suggestive of glazing, seems to support this.

¹ W. M. Flinders Petrie, *Tell el Amarna*, p. 25.

² M. Hamza, *op. cit.*, pp. 31-68.

At what period glass objects were first made in Egypt is uncertain, but the regular production on a large scale dates from about the beginning of the Eighteenth Dynasty and by the middle of the dynasty the technique had reached a very high standard of excellence. The earliest known piece of glass dated by an inscription is from the beginning of this dynasty and is a large green ball bead bearing the name of Amenophis I which is now in the Ashmolean Museum at Oxford. The most important known specimens of Egyptian glass dating from the Eighteenth Dynasty to the Twenty-first Dynasty inclusive (excepting the few glass vessels and the large amount of glass inlay from the tomb of Tut-ankhamûn, which have not yet been published) have been summarized by Newberry.¹ The earliest specimen of transparent glass of which any record can be found is a large ball bead of 'dark-blue clear glass' of the early Eighteenth Dynasty found by Wainwright at Balabish² and small pieces of colourless transparent glass also occur as inlay on some of the objects from the tomb of Tut-ankhamûn.

As the production of glass in Egypt before the Eighteenth Dynasty has been disputed, the principal glass objects of earlier date found in the country may be summarized and are as follows :

Date.	Object.	Reference.
Predynastic	Hathor head	Petrie, <i>Prehistoric Egypt</i> , p. 43.
Predynastic	Bead	Neumann & Kotyga, <i>Z. f. angew. Chem.</i> , 1925, p. 776.
Predynastic	Beads	MacIver & Mace, <i>El Amrah and Abydos</i> , p. 54.
1st Dynasty	Inlay	Amélineau, <i>Les Nouvelles Fouilles d'Abydos, 1895-1896</i> , pp. 128, 306; Pl. XXXI.
VIIth-VIIIth Dyn.	Bead }	H. C. Beck, in <i>Qau and Badari II</i> (G. Brunton), p. 25.
IXth-Xth Dyn.	Bead }	
Xth Dynasty	Uzat eyes (two)	Petrie and Brunton, <i>Sedment I</i> , p. 6.
XIth Dynasty	Beads	H. E. Winlock, <i>Bull. Met. Mus. of Art, N.Y. Egypt. Exped.</i> , II (1921), p. 52.

¹ P. E. Newberry, *A Glass Chalice of Tuthmosis III*, in *Journal of Egyptian Archaeology*, VI (1920), pp. 155-60.

² G. A. Wainwright, *The Excavations at Balabish: Preliminary Notice*, in *Journal of Egyptian Archaeology*, II (1915), p. 203.

<i>Date.</i>	<i>Object.</i>	<i>Reference.</i>
XIIth Dynasty	Eye and piece	H. D. Parodi, <i>La Verrerie en Egypte</i> , pp. 29-30.
XIIth Dynasty	Light-blue bead	H. C. Beck (not yet published).
XIIth Dynasty	Mosaic of Amenemmes III	Newberry, <i>op. cit.</i> , p. 159.
2nd Inter. Period	Bead	Petrie and Brunton, <i>op. cit.</i> , p. 16.
2nd Inter. Period	Beads	G. Brunton, <i>Qau and Badari III</i> , p. 11.
2nd Inter. Period	Blue glass vase	G. Brunton, <i>op. cit.</i> , p. 8.

As may be seen from the above list, the glass objects attributed to periods earlier than the Eighteenth Dynasty are very few and the correctness of the dating of some of these has been doubted. Thus, although Petrie says¹ with reference to the Hathor head that 'The grave is well dated by eight types of pottery,' possibly the object may have been found elsewhere and temporarily deposited by the workman, who found it, for safety or for ease of transport (without any thought of wrongdoing) in the small vase in which Petrie first saw it. Von Bissing doubts the date of the mosaic of Amenemmes III and thinks it is of Roman age,² though Newberry disputes this and states³ 'That this is contemporary with the king whose name it bears appears to me certain.' The two specimens analysed by Parodi are stated by him⁴ to be a transparent eye and a fragment of yellow glass respectively, both from the tomb of princess Khnûmet of the Twelfth Dynasty at Dahshûr and to have been given to him by Maspero. From the analytical results obtained there can be no doubt that the material analysed was glass, which is extraordinary, not merely on account of the early date attributed to it, but more especially because in the Cairo Museum there are several eyes from the tomb of the same princess, each of which has a transparent cornea looking very like glass, but which the author has examined and believes to be transparent quartz (rock crystal) and some mistake,

¹ W. M. Flinders Petrie, *op. cit.*, p. 43.

² F. W. von Bissing, *Sur l'histoire du verre en Egypte*, in *Revue Archéologique*, xi (1908), p. 213.

³ P. E. Newberry, *op. cit.*, p. 159.

⁴ H. D. Parodi, *op. cit.*, pp. 29-30.

therefore, either in the identity of the specimens or in the dating is suggested.

But, in addition to the possible mistakes just mentioned, other mistakes in connexion with early glass have been made, for example, the greenish-blue material in the First Dynasty bracelets found by Petrie at Abydos and thought by Vernier to be glass¹ is not glass, but turquoise, as described by the finder, as is also the similar material in the Twelfth Dynasty jewellery from Dahshûr, also queried by Vernier.² The mosaic from Dahshûr, which is a small pendant with the figure of an ox on a light blue ground, thought by Newberry to be glass,³ is believed by the author to be a mosaic of coloured stones inlaid in a blue stone background (the whole having been ground down until very thin and the joining obliterated in the process), the black marks on the ox, however, possibly being natural marks on the stone. The cover is rock crystal and neither Iceland spar (*spath* as stated by the finder)⁴ nor fluor spar as suggested by Newberry.

Most people are familiar with Pliny's story of the discovery of glass,⁵ which is that a ship laden with natron (probably from Egypt) being moored at a certain spot on the shore of Phoenicia, 'the merchants, while preparing their repast upon the sea-shore, finding no stones at hand for supporting their cauldrons, employed for the purpose some lumps of natron which they had taken from the vessel' which the heat of the fire caused to combine with the sand and so produced glass. While this is certainly apocryphal, so far as the date and place are concerned, it is a perfectly feasible method of accidentally making a small quantity of glass and is by no means so fantastic as is often represented, those who criticize it adversely assuming wrongly that the sand must necessarily have been wholly siliceous and therefore that only sodium silicate, which is not glass, could possibly have been formed. But it is highly probable that the sand on the shore of Phoenicia was a quartz

¹ E. Vernier, *Bijoux et orfèvreries*, Cat. Gén. du Musée du Caire, pp. 10-11, 13-14.

² E. Vernier, pp. 88, 298, 299, 307, 336.

³ P. E. Newberry, *op. cit.*, p. 159.

⁴ J. de Morgan, *Fouilles à Dabchour*, p. 67.

⁵ xxxvi, 65.

sand containing calcium carbonate, as is the case with much of the sand on the northern shore of Egypt, and such a sand, when fused with natron, will produce a soda-lime silicate, or true glass.

The remains of a number of glass works have been found in Egypt, the earliest being at Thebes and dates from the reign of Amenophis III ^{1, 2} (late Eighteenth Dynasty): three or four are at El-Amârna and belong to the reign of Akhenaton ³: others of the Twentieth Dynasty are at Lisht ^{1, 4} and Menshîyeh respectively ¹: others again, of which the dates are not known, occur in the Wâdi Natrûn ⁵ and to the south and south-west of Lake Mareotis ⁵ respectively and one of Ptolemaic date is at Nebêsheh.⁶

Alexandria was one of the greatest glass manufacturing centres of antiquity and Strabo (first century B.C. to first century A.D.) states ⁷ that he 'heard at Alexandria from the glass-workers that there is in Egypt a kind of vitrifiable earth, without which expensive works in glass could not be executed . . .' In the literature of Roman times there are a number of references to Egyptian glass and under the emperor Aurelian there was a tax on glass imported into Rome from Egypt.

Composition

Ancient Egyptian glass is essentially a soda-lime silicate similar in the nature, though not in the proportions, of its constituents to a modern glass of ordinary quality, the latter of which however contains much more silica, a much smaller proportion of oxides of iron and aluminium, generally no oxide of manganese, much more lime, practically no magnesia and much less alkali.

¹ P. E. Newberry, *op. cit.*, p. 156.

² A. M. Lythgoe, *Egypt. Exped. 1916-17*, *Bull. Met. Mus. of Art, New York*, 1918, p. 6.

³ W. M. Flinders Petrie, *Tell el Amarna*, p. 25.

⁴ A. C. Mace, *The Murch Collection of Egyptian Antiquities*, in Supplement to *Bull. Met. Mus. of Art, New York*, 1911, p. 25.

⁵ P. E. Newberry, *op. cit.*, p. 160. One of these has been seen by the author.

⁶ F. Ll. Griffith, in *Nebesbab and Defenneh*, W. M. Flinders Petrie, p. 42.

⁷ xvi, 11, 25.

The lower proportion of silica and lime, the greater proportion of oxide of iron and the considerably higher proportion of alkali in ancient Egyptian glass, as compared with modern glass, would all have acted in the way of materially lowering the temperature required for fusion, which was an important consideration and would have made the working of the glass easier, but at the same time the quality of the product would have been adversely affected, such glass being much less resistant to atmospheric influences that produce decay, especially damp. Another great difference between ancient and modern glass is that the latter, being largely employed to transmit light, is generally transparent, whereas the former, not having been needed for that purpose, but being mainly ornamental, though sometimes translucent and even occasionally transparent, was more generally opaque.

From the high proportion of oxides of iron and aluminium shown by the analyses and from the presence of oxide of manganese and of magnesia, the glass represented was manifestly not made from pure materials and the composition corresponds to what would be obtained by fusing together a mixture of sand and natron, neither of which are chemically pure substances, provided the sand contained, as it often does in Egypt, a certain proportion of calcium carbonate.

When yellow sand is used for glass making, the iron compounds present, to which the yellow colour is due, tend to produce a green colour in the glass, but in most ancient Egyptian glass, except the blue, this would not have greatly mattered and in some instances it is possible that the effects of the iron might have been neutralized by the oxide of manganese naturally present, which is a substance employed for this purpose in modern glass making. Quartz sand, however, containing only a small amount of iron and having very little colour occurs plentifully in Egypt and might have been used for special work.

It has been stated that glass was made at El-Amârna from pure silica obtained by crushing quartz pebbles,¹ but this does not seem to agree with the original account as published,² according to which quartz pebbles were found only in con-

¹ W. M. Flinders Petrie, *The Arts and Crafts of Ancient Egypt*, 1910, p. 124.

² W. M. Flinders Petrie, *Tell el Amarna*, pp. 25-7.

nexion with the manufacture of blue frit, where freedom from iron is essential, and not for glass making, and the evidence from the analyses,¹ which cannot be ignored, points to the use of sand. If quartz pebbles, or other form of pure silica, had been used it would have been necessary to have added calcium carbonate (carbonate of lime) also, as lime is an essential constituent of the ancient glass, but with sand, the carbonate of lime would have been present as an impurity and its presence would not even have been known to the glass maker, who would merely have realized that in order to produce a satisfactory product a particular kind of sand was required.

From the analyses¹ it will be seen that the alkali is largely in the form of soda and that although potash is sometimes also present, it is generally only in very small proportion. This means that the alkali employed in the specimens analysed was natron, which consists of sodium carbonate and sodium bicarbonate, and not plant ashes, in which the alkali is chiefly potash. Where only a trace of potash is present this probably occurred as an impurity in the natron, in which it is usually present in very small amount, but where there is a notable amount of potash this points to the use of plant ashes or to a mixture of these with natron.

The colour of ancient Egyptian glass may be amethyst, black, blue, green, red, white or yellow, and the nature of the various colouring matters may now be considered.

Amethyst Glass. Two specimens of dark amethyst coloured glass, both of the Twentieth Dynasty, analysed by the author, were found to owe their colour to a manganese compound, and Neumann and Kotyga² found this same colouring matter in a purple glass of the Eighteenth Dynasty. In this connexion it may be mentioned that white glass of ordinary quality containing manganese compounds becomes coloured if exposed to strong sunlight for some time.³ The colour so produced varies from a very slight amethyst tint to a beautiful deep purple colour, and it is a matter of common observation in Egypt to find

¹ See pp. 419-21.

² B. Neumann and G. Kotyga, *Z. für angew. Chem.*, 38 (1925), p. 863.

³ A. Lucas, *Effects of Exposure on Colourless Glass*, in *Cairo Scientific Journal*, xi (1922-3), pp. 72-3.

in the desert in the neighbourhood of towns, pieces of what have been white glass coloured in this manner. The coloration is due to manganese compounds in the glass having undergone some chemical change, which apparently is brought about by sunlight and is not caused either by heat or radio-activity, though the latter also produces a similar coloration. It is not of course suggested that the colour of ancient amethyst glass has been caused by exposure, or that it is other than original.

Black Glass. The author has been unable to obtain any specimen of ancient Egyptian black glass for analysis, nor does Parodi give any analyses of this glass, but Neumann and Kotyga found that the colouring matter in two instances was due to copper and manganese compounds and in a third case to a large proportion of an iron compound.¹

Blue Glass. The ancient Egyptian blue glass is of three different shades of colour, namely, dark blue imitating lapis lazuli; light blue imitating turquoise, and greenish blue. Of the specimens analysed by the author, three of the Eighteenth Dynasty and two of the Twentieth Dynasty all owed their colour to copper compounds: one specimen of dark blue glass from the tomb of Tut-ankhamûn analysed by Mr. W. B. Pollard for the author was found to be coloured by a cobalt compound²: a sample of blue Arab glass analysed for the author by Mr. J. Clifford was free from copper compounds, its colour being due to an iron compound, as was also the case with two specimens of blue glass of the Ptolemaic period analysed for the author by Dr. H. E. Cox: Parodi found copper compounds as the colouring matter in one specimen of Egyptian blue glass of Persian times³ and cobalt compounds in seven specimens, four of the Eighteenth Dynasty, two of the Twentieth Dynasty and one of the Persian period:³ cobalt compounds were also found by Clemm and by Clemm and Jehn,⁴ working in the laboratory of A. W. Hofmann (unfor-

¹ B. Neumann and G. Kotyga, *op. cit.*, p. 864.

² A. Lucas, *Appendix*, II, p. 171, in *The Tomb of Tut-ankh-Amen*, II, Howard Carter.

³ H. D. Parodi, *op. cit.*, pp. 31, 33, 34, 38, 73.

⁴ C. R. Lepsius, *Les métaux dans les inscriptions Égyptiennes*, trans. W. Berend, 1877, pp. 26-7.

tunately the dates of the specimens are not given) and Lepsius, who quotes the analyses, mentions several other specimens in which cobalt compounds were present : Neumann and Kotyga did not find cobalt compounds in any of the thirty-eight specimens of ancient Egyptian blue glass they examined and state that these were never used until Venetian times and that the colour is generally due to copper compounds, but occasionally to iron compounds.¹

Cobalt compounds are used for colouring blue glass at the present day ; but as they only produce a dark blue colour, the turquoise blue and the greenish-blue of some of the Egyptian glass cannot ever be due to their use. The finding of cobalt in Egyptian glass, especially at so early a date as the Eighteenth Dynasty, is of considerable importance, since cobalt compounds do not occur in Egypt except as traces in other minerals,² and their presence in the glass, if confirmed, would seem to indicate that the Egyptian glass makers of that time were in contact with glass makers elsewhere, who were using this material. Even in countries where cobalt ore occurs (for example Persia and the Caucasus region) its use at an early period would be of interest, as the ore is not blue and, therefore, its value as a colouring agent is not naturally suggested, but in Egypt, where the ore is not found naturally, its use would be still more interesting.

The usual test for cobalt compounds, which is both sensitive and characteristic, is by means of a borax bead in the flame of a Bunsen lamp or blowpipe, cobalt compounds colouring the bead a transparent, bright blue, both in the inner (reducing) and outer (oxidizing) flame, but since copper compounds also give a blue bead in the outer (oxidizing) though not in the inner (reducing) flame, there is some slight possibility of a mistake between the two. In many of the cases mentioned in which cobalt compounds have been reported, the nature of the test applied is not given, but in two of them (that of Mr. Pollard and one of those quoted by Lepsius) the borax bead test was relied on. In one specimen analysed by Clemm and Jehn, the cobalt was determined quantitatively and, in duplicate analyses, amounted to 2.86 and 2.82 per cent respectively

¹ B. Neumann and G. Kotyga, *op. cit.*, pp. 862-3.

² See p. 217.

expressed in terms of the oxide and in a specimen analysed by Clemm, also quantitatively, there was 0.95 per cent of cobalt oxide. Even though the determination of cobalt about sixty years ago may not have been quite as accurate as would be the case to-day, it is unlikely that the analyses should be wholly wrong. The present position of the matter, therefore, is that there is a small amount of direct evidence for the presence of cobalt compounds in the ancient Egyptian glass; but since this would be extraordinary and is denied by Neumann and Kotyga, and since it would either prove a direct connexion between the Egyptian glass makers of the Eighteenth Dynasty and those of western Asia, or that the specimens of glass analysed were not of Egyptian manufacture but imported, either of which would be most important facts in the early history of glass making, it is manifestly desirable that more analyses should be made, so as to place the matter beyond doubt.

Green Glass. A green colour in glass may be due either to compounds of copper or of iron, the colour of the modern green bottle-glass, for example, being produced by the latter. It is to a copper compound, however, that the green of the ancient Egyptian glass is due. One specimen of Eighteenth Dynasty date analysed by the author was coloured by copper; also one of the Twentieth Dynasty examined by Parodi,¹ and Neumann and Kotyga found copper compounds to be the colouring matter of all the specimens of Egyptian green glass examined by them.²

Red Glass. The colour of the Egyptian red glass is due to red oxide of copper. This is evident from the green coating that forms on the surface when the glass decays and is confirmed by analysis. Two specimens of this glass, one from the Eighteenth Dynasty and the other from the Nineteenth Dynasty, analysed by the author were both found to owe their colour to a copper compound and the same result was found by Neumann and Kotyga.³

White Glass. When glass is colourless and transparent or translucent it naturally does not contain any colouring matter, but when it is white and opaque this effect is generally produced

¹ H. D. Parodi, *op. cit.*, pp. 36, 69.

² B. Neumann and G. Kotyga, *op. cit.*, p. 858.

³ B. Neumann and G. Kotyga, p. 864.

by the addition of oxide of tin, which has been found in white opaque glass of the end of the Eighteenth Dynasty¹ and also of the Twentieth Dynasty and later.^{1, 2} A specimen of tin oxide, almost certainly artificially prepared, was found in the tomb of Tut-ankhamûn, which may possibly have been for use in making white opaque glass.³

Yellow Glass. A specimen of Egyptian yellow glass of the Nineteenth Dynasty was found by the author to be coloured by a compound of antimony and lead and these same ingredients were found by Parodi in Egyptian yellow glass of both Persian and Arab times.⁴ The specimen analysed by Neumann and Kotyga owed its colour to an iron compound.⁵

Manufacture

The process of glass making has been described by Petrie⁶ and that of fashioning the finished glass into beads, mosaics and vases by Petrie⁶ and into vases by Newberry.⁷

The raw materials—(a) quartz sand containing calcium carbonate; (b) natron or plant ashes, but generally the former; and (c) the colouring matter—were put into small crucibles, (at El-Amârna two or three inches in both depth and diameter) and strongly heated until complete combination and fusion resulted and the main bulk of the glass became homogeneous and clear. In order to know when this end point was reached, small quantities of the fused mass were taken out by means of pincers from time to time and examined. When finished, the glass was allowed to cool in the crucibles, which were finally broken away, as also the frothy upper surface (caused by the escape of carbon dioxide and combined water) and the dirty lower surface (due to impurities and dirt sinking to the bottom). The irregularly shaped lumps of glass were broken up into suitable pieces, which were softened by heat and then

¹ B. Neumann and G. Kotyga, *op. cit.*, p. 863.

² H. D. Parodi, *op. cit.*, pp. 34, 45, 73.

³ See p. 210.

⁴ H. D. Parodi, *op. cit.*, pp. 36, 69.

⁵ B. Neumann and G. Kotyga, *op. cit.*, pp. 863-4.

⁶ W. M. Flinders Petrie, *Tell el Amarna*, pp. 26-7; *The Arts and Crafts of Ancient Egypt*, pp. 120-5.

⁷ P. E. Newberry, *op. cit.*, pp. 157-8.

rolled out into thin round rods, some of which were made still thinner by drawing them out after they had been again softened by heating. Sometimes the rods were flattened into strips, which were cut up to make small pieces for inlay, the larger and more elaborate pieces of inlay being moulded.

Until a late period, beads were made by winding thin glass threads round a copper wire, which was withdrawn when the glass was cold, which on account of the greater shrinkage of the copper than of the glass could easily be done. During the Coptic period a different method was employed, namely, by drawing out a glass tube to the required diameter and then cutting it into beads.

Vases were always formed on a sandy clay core to which a copper rod was attached as a handle. Petrie at first stated that the core was covered with glass by being dipped into the molten material,¹ but later he says that on the core 'glass cane was wound hot until it was uniformly coated.'² The glass was then reheated until the rods coalesced. If a pattern were required, this was made by softening the glass by heating and then winding round it glass threads of various colours, the very common wavy effect being produced by dragging the coloured rods up and down while still hot. The whole was then 'rolled to and fro so as to bed in the threads and make a smooth surface.'² The rim, foot and handle (if any) were added separately. One objection to the dipping of the core into the molten glass as originally suggested by Petrie, is that this would require a larger crucible and a greater volume of melted glass than probably the Egyptians were capable of dealing with until a late period. Small figures and certain other objects, such as the larger and more elaborate pieces of inlay can only have been made by moulding³: blown glass was not known until the Roman period.

Glass inlay is often called enamel, paste or *pâte de verre*: it is certainly not enamel, which, although a vitreous material, is employed in the powdered state and always fused into position

¹ W. M. Flinders Petrie, *Tell el Amarna*, p. 27.

² W. M. Flinders Petrie, *The Arts and Crafts of Ancient Egypt*, p. 125.

³ Griffith found both limestone and terra-cotta moulds for glass of Ptolemaic date (F. Ll. Griffith, in *Nebesheh and Defenneh*, W. M. Flinders Petrie, p. 42).

by heat, whereas the ancient Egyptian material was always cut or moulded and cemented into position : the terms paste and *pâte de verre* are unsatisfactory, because meaningless, and they are often used very loosely and sometimes are even intended to be non-committal. The word paste, too, in connexion with glass has a very definite technical meaning and signifies the glass with a high refractive index and high lustre employed to imitate certain modern gems, particularly the diamond, and it cannot correctly be used to describe the soft glass without brilliance or sparkle made by the ancient Egyptians in imitation of precious stones. It is suggested, therefore, that the terms paste and *pâte de verre* should be discarded and that the material should always be called what it is, namely glass.

CHAPTER VI

FIBRES

Under the head of fibres it is proposed to deal with, not only the fibres employed for making Woven Fabrics, but also, though very briefly, those used for Basketry, Brushes, Cordage, Matting and Paper, which may conveniently be done in alphabetical order.

BASKETRY

The making of baskets, or plaiting, was one of the first arts practised by primitive man, being earlier than weaving, of which, as pointed out by Lucretius, it is but the first step, and manifestly it is the simpler of the two, since in basketry, no other preparation of the fibre is necessary beyond the selection and cutting into lengths, with sometimes, as in the case of palm leaves, the splitting into suitable widths, whereas before weaving is possible there must always be some preliminary treatment, thus all fibres must be spun before they can be woven and certain stems (i.e. flax), which are composed of bundles of fibres enclosed in woody tissue, must not only be separated into their component parts, but these must be cleaned from adherent material before they can be employed. Also, baskets are made without the use of any kind of machinery, whereas the appliances of distaff, whorl and spindle are required for spinning and a machine (the loom) for weaving, before woven fabrics can be produced.

In Egypt, the making of baskets dates back to neolithic times,¹ which probably came to an end about 7,000 years ago.

¹ G. Caton-Thompson, *The Neolithic Industry of the Northern Fayum Desert*, in *Journal Royal Anthropol. Inst.*, LVI (1926), p. 315.

The subject of basket making in ancient Egypt is one that has been very little studied, either with regard to the materials or to the technique of the methods employed, and although numerous references can be found to materials stated to have been used, these statements are of such different values, and some are of such doubtful worth, that any list of them would be misleading.

The principal materials employed were the leaves of the date palm both for coil and wrapping (the whole leaf being used for coarse work, but being split into narrow strips for finer work), with sometimes the split mid-rib of the branches of the date palm for foundations.¹ In the south, the leaves of the dôm palm were often substituted for those of the date palm. The use of both date palm leaf and dôm palm leaf by the Egyptians for plaiting is mentioned by Theophrastus.² These materials are still employed for basketry at the present day.³

Less frequent materials were grasses and other plant stems. Grass is recorded as having been used for basketry of neolithic age⁴ and at various periods since, among which specimens of Badarian⁵ and of Christian⁶ dates respectively may be mentioned, but unfortunately the particular kind of grass has not been identified. In the latter case, however, ropes and mats found at the same place were made of halfa grass (a strong, tough, wild grass that grows abundantly in north Africa, including Egypt) and possibly, therefore, the baskets too may have been made of this material. Newberry states⁷ that 'Two species of grass were used in the manufacture of basket-work,' but the species are not named. Sometimes the coil of a basket is of grass and the wrapping of split palm leaf.

But grass was not the only plant stem employed, the use of others being known from neolithic,⁴ Badarian⁵ and proto-

¹ Winifred S. Blackman, *The Fellāhīn of Upper Egypt*, p. 304.

² *Enquiry into Plants*, IV, 2, 7.

³ Winifred S. Blackman, *op. cit.*, pp. 155-61.

⁴ G. Caton-Thompson, *Explorations in the Northern Fayum*, in *Antiquity*, I (1927), p. 335.

⁵ G. Brunton and G. Caton-Thompson, *op. cit.*, pp. 62-3.

⁶ H. E. Winlock and W. E. Crum, *op. cit.*, p. 74.

⁷ P. E. Newberry, *On the Vegetable Remains*, in *Hawara, Biabmu and Arsinoe*, W. M. Flinders Petrie, p. 52.

dynastic times¹ respectively. At the two earlier dates the stems were those of a dicotyledonous plant, the Badarian specimen being possibly a species of flax. The later specimens were several vase covers of predynastic or protodynastic date and two basketry coffins of the latter period, the material of which has been identified by Keimer as the stems of *Ceruana pratensis* FORSK, a small plant well known in Egypt.

In the author's opinion, it is very doubtful whether papyrus, rushes or reeds, sometimes stated to have been used, were ever employed for basket making in ancient Egypt though they were extensively utilized for other purposes. Thus papyrus, often associated with reeds, was used for making receptacles, which are better described as boxes rather than baskets, since basketry, as the term is here used, means a simple kind of weaving necessitating the plaiting or interlacing of the fibres, whereas these objects are not plaited. Petrie says² that 'Flat papyrus slices of the outer brown skin were greatly used for making boxes for food, framed on lengths of reed lashed together.' He also reports the finding of 'papyrus or reed boxes'³ and 'four boxes of papyrus stems bound with palm rope,'³ though an illustration of what is probably one of the 'boxes' just mentioned, is called a 'papyrus basket.'³ Quibell, recording an object of this nature from the tomb of Yuya and Thuyu, calls it a basket⁴: it consists of a large oblong receptacle for wigs in the form of a dwelling house and is described as being made of papyrus stems, papyrus pith and reeds. A papyrus box found in the tomb of Tut-ankhamûn, described by Carter as 'a papyrus basket belonging to the King's writing outfit,'⁵ so far as can be seen, appears to be made of thin slices of papyrus pith on a framework of reeds: it is lined with linen and is decorated on the top and front with narrow strips of a glossy vegetable material, probably straw, and two small gilt and painted pictures. Another box from the same tomb, which is

¹ L. Keimer, *Ceruana pratensis* FORSK dans l'Égypte ancienne et moderne, in *Annales du Service*, xxxii (1932), pp. 30-7.

² W. M. Flinders Petrie, *Social Life in Ancient Egypt*, p. 143.

³ W. M. Flinders Petrie, *Deshasch*, pp. 34-5; Pl. XXXIV.

⁴ J. E. Quibell, *The Tomb of Yuaa and Thuiu*, in *Cat. Gén. du Musée du Caire*, pp. 57-8; Pl. XLVIII.

⁵ Howard Carter, *op. cit.*, III, p. 215; Pl. LXVI.

divided into six compartments, is made of a framework and panels of reeds lined with slices of papyrus pith.

Reeds, which are special kinds of water-loving grasses, are generally firm-stemmed and, therefore, although admirably adapted for the framework of boxes, they are not suitable for basketry, since they do not possess the required pliability: they were sometimes used for making coffins^{1, 2, 3} and a particular kind of reed, *Phragmites aegyptiaca*, was employed for making arrows and at a late date for pens.

Both Miss Blackman⁴ and Wainwright⁵ have described a few ancient baskets, which they compare in regard to material and technique with modern baskets and state that they are almost identical.

The ancient baskets were often decorated, thus Wainwright says⁶ that '... many XVIIIth dynasty baskets show regular patterns carried out in colours,' and again that 'small or finely made ones ... are quite commonly decorated in colour, while larger ones ... often have seams of ornamental stitching running up their sides.' Carter points out that some of the baskets from the tomb of Tut-ankhamûn have patterns formed by interweaving dyed fibres with undyed fibres.⁷ Petrie describes certain baskets of Twelfth Dynasty date as having woven patterns on the sides⁸; one from the Eighteenth Dynasty as being red and black⁹ and one of the Roman period as red and white.⁹

Basketry work was also employed for sieves, which 'are well known from dynastic times.'¹⁰ A specimen of Eighteenth Dynasty date had a 'mesh with a web of palm fibre crossed by warp of palm leaf,' the edging being of palm fibre bound with

¹ G. Brunton, *Qau and Badari I*, pp. 13, 22, 31, 32, 47.

² W. M. Flinders Petrie, *Deshaseh*, p. 34.

³ A. Rowe, *The Museum Journal*, Philadelphia, xxii (1931), p. 27.

⁴ W. S. Blackman, *op. cit.*, p. 304.

⁵ G. A. Wainwright, (a) *Basketry, Cordage, etc., from the Fayum*, in *Annales du Service*, xxiv (1924), pp. 108-11; (b) *Ancient Survivals in Modern Africa*, in *Bull. Soc. Sult. de Géog.*, Cairo, ix (1919), pp. 177-9.

⁶ G. A. Wainwright, *op. cit.* (a).

⁷ Howard Carter, *op. cit.*, p. 149.

⁸ W. M. Flinders Petrie, *Illahun, Kabun and Gurob*, p. 21.

⁹ W. M. Flinders Petrie, *Objects of Daily Use*, pp. 48-9.

¹⁰ H. E. Winlock and W. E. Crum, *The Monastery of Epiphanius at Thebes*, p. 63.

palm leaf.¹ An example found by Winlock from a Christian Monastery at Thebes 'had a rim made of two cords of grass wrapped around and bound together with palm leaf and a mesh made of small reeds laced together with grass and reinforced at the back with two palm sticks. . . .'²

BRUSHES

Brushes were in common use in ancient Egypt and have often been found: they were all made of vegetable fibre, though not always of the same sort of fibre, and were essentially of three kinds, namely, (a) bundles of coarse fibre or twigs bound together at the top with thin rope, string or palm leaf, so as to form a handle, separate wooden handles not being used; (b) bundles of finer fibre, though of different degrees of fineness, doubled into half their length and lashed together at the doubled end, and (c) pieces of fibrous wood and also thin rushes bruised at one end until the fibres separated and formed bristles.

As examples of the first kind may be mentioned the fan-shaped brushes of split reeds used both for sweeping the floor and for fanning the charcoal used for cooking, referred to and illustrated by Petrie^{3, 4}; the brush made of the fruit-stalks of dates found by Quibell⁵ and the brushes formed of the twigs of *Ceruana pratensis* mentioned by Keimer.⁶ Muschler, in his description of this plant, says,⁷ 'Generally used for making little brooms, found . . . in old Egyptian tombs,' and it is still largely used for brush making in Egypt at the present day.⁶

Examples of the second kind are the five brushes of palm fibre of Roman date illustrated by Petrie⁸ and those from the Monastery of Epiphanius described by Winlock,⁹ some of which

¹ T. E. Peet and C. L. Woolley, *The City of Akhenaten*, I, p. 74.

² H. E. Winlock and W. E. Crum, *op. cit.*, p. 63.

³ W. M. Flinders Petrie, *Social Life in Ancient Egypt*, p. 143.

⁴ W. M. Flinders Petrie, *Objects of Daily Use*, p. 49; Pl. XLII (178).

⁵ J. E. Quibell, *Excavations at Saqqara* (1908-9; 1909-10), *The Monastery of Apa Jeremias*, p. 17.

⁶ L. Keimer, *op. cit.*, pp. 32-3.

⁷ R. Muschler, *A Manual Flora of Egypt*, II, p. 969.

⁸ W. M. Flinders Petrie, (a) *Hawara, Biabmu and Arsinoe*, p. 11; Pl. XIII (24, 25); (b) *Objects of Daily Use*, p. 49; Pl. XLII (179-84).

⁹ H. E. Winlock and W. E. Crum, *op. cit.*, p. 75.

were made of halfa grass and some of split palm leaf, the first-named material being used for the smaller brushes and the second for the larger ones. Small stumpy brushes of this sort were employed for painting and one such was found by de Garis Davies as part of a tomb painter's outfit,¹ two by Peet and Woolley² and two others by Pendlebury,³ several being still clogged with the ancient paint. These paint brushes resemble very much in general appearance a certain kind of modern shaving brush.

The wooden brushes of the third kind described were probably used exclusively for painting and those made from rushes were for writing. Ten specimens of the former were among the tomb painter's outfit mentioned.¹ These, as already explained, consist of pieces of fibrous wood of different thicknesses, probably all portions of the mid-rib of the branches of the date palm, which have been bruised at one end until the fibres have separated and formed coarse bristles, and they still have on them the ancient paint. The brushes used for writing, as proved by numerous specimens that have been preserved, consist of a particular kind of rush (not reed, as generally stated), *Juncus maritimus*, that grows plentifully in Egypt at the present day (generally in salt marshes): portions of the required length of this were taken and one end, after being cut slantingly, was bruised, possibly with the teeth, to separate the fibres and to make it into a brush. Eleven specimens from the Eighteenth Dynasty measured by the author varied from 6.3 inches (16 cm.) to 9 inches (23 cm.) in length and were all approximately one-sixteenth of an inch (1.5 mm.) in diameter. A bunch from the Twelfth Dynasty measured by Quibell were all 16 inches long and one-tenth of an inch in diameter.⁴ Such an article, although generally called a pen, is a brush and the true pen, which was several times the thickness of the brush, was made from a reed, *Phragmites aegyptiaca*, cut to a point and split in the manner of the quill pen formerly employed in Europe. This reed, which was used by both the Greeks and Romans

¹ N. de G. Davies, *Five Theban Tombs*, pp. 5-6; Pl. XVII.

² T. E. Peet and C. L. Woolley, *The City of Akhenaten*, I, p. 76.

³ J. D. S. Pendlebury, in *The Illustrated London News*, 19th March, 1933.

⁴ J. E. Quibell, *The Ramesseum*, p. 3.

'from the 3rd century B.C. onwards'¹ was doubtless the Egyptian reed mentioned by Pliny (first century A.D.) as being employed for writing.² Petrie illustrates a number of these pens of Roman date found by him in Egypt.³ Winlock says¹ that 'The complete adoption of the split pen by the Egyptians may be safely related to the adoption of the Greek alphabet for writing the Egyptian language during the 4th century A.D.' The monks of the Christian Monastery of Epiphanius at Thebes in the sixth or seventh century A.D. were using split pens. 'The pens were made of reeds, which averaged about 1 cm. in diameter. An unused new pen . . . was 26.5 cm. long. The old pens had been resharpened so often that finally they were mere stumps less than 6 cm. long . . . and one of them had been lengthened by sticking a bit of wood into the end.'¹ Pens of this kind are still being employed in Egypt at the present day, though their use is gradually dying out.

CORDAGE

Although no detailed study of the ropes and twines of ancient Egypt has been made, a certain number of facts relating to them are known, which may now be considered.

Rope making consists in twisting separate fine fibres into a cord, as in spinning, and then twisting a number of cords round one another. Rope was known in Egypt from very remote times, the earliest specimen of which any record can be traced being one from the predynastic period, which was made of flax fibre.⁴ Similar rope has also been found from the Twelfth Dynasty.⁵ A rope of Sixth Dynasty date was composed of the fibres of a monocotyledonous plant, possibly halfa grass,⁶ which was also being used, as well as date palm fibre, as late as the sixth or seventh century A.D.⁷ It was the latter, however,

¹ H. E. Winlock and W. E. Crum, *op. cit.*, pp. 93-4.

² xvi, 64.

³ W. M. Flinders Petrie, *Objects of Daily Use*, Pl. LVIII (54, 55, 56, 58).

⁴ G. Brunton and G. Caton-Thompson, *op. cit.*, p. 67.

⁵ W. M. Flinders Petrie, *Kahun, Gurob and Hawara*, pp. 28, 35.

⁶ G. Brunton, *Qau and Badari I*, p. 71.

⁷ H. E. Winlock and W. E. Crum, *op. cit.*, p. 72.

(palm fibre) that was generally employed for rope making in ancient Egypt and it is still used to-day for the same purpose : it consists of the fibres from the fabric-like material that grows at the crown of the trunk of the date palm, surrounding the base of the branches.

Theophrastus¹ and Pliny² both state that the Egyptians made ropes of papyru, and in two rope making scenes depicted on tomb walls, one of the Fifth Dynasty³ and the other probably of the Eighteenth Dynasty,⁴ the material being employed is apparently papyrus, but the only record of the finding of papyrus rope that can be traced is one by Petrie, who refers to 'papyrus cord.'⁵

A number of specimens of string of Eighteenth Dynasty date examined by the author were all made of flax fibre.

MATTING

The making of mats has always been, as it still is, one of the important minor industries of Egypt, and mats have been found in graves from the Badarian and predynastic periods onwards, the body frequently resting on a mat, or being covered with, or wrapped in, a mat. Mat making is illustrated in a Twelfth Dynasty tomb at Beni Hasan.⁶

The materials principally used for the ancient mats are generally stated to have been either reeds or rushes, but these terms are often employed loosely and incorrectly and the subject of ancient Egyptian mat making needs further work.

Some of the Badarian⁷ and predynastic^{7, 8} matting was made of reeds and some of rushes : matting from the Fifth Dynasty at Abusîr was composed of palm-ribs and palm fibre⁹ and matting of Sixth Dynasty date from the Qâw-Badari district

¹ *Op. cit.*, IV, 8, 4.

² XIII, 22.

³ N. de G. Davies, *The Mastaba of Ptahhetep and Akhethetep*, I, Pl. XXV.

⁴ E. Mackay, *Note on a New Tomb (No. 260) at Drab Abu'l Naga, Thebes*, in *Journal of Egyptian Archaeology*, III (1916), pp. 125-6 ; Pl. XV.

⁵ W. M. Flinders Petrie, *Deshasheh*, p. 33.

⁶ P. E. Newberry, *Beni Hasan*, II, Pl. XIII.

⁷ G. Brunton and G. Caton-Thompson, *op. cit.*, p. 67.

⁸ R. MacIver and A. C. Mace, *El Amrah and Abydos*, p. 31 ; Pl. XI (5, 6).

⁹ H. Schafer, *Priestergräber von Totentempel des Ne-User-Rê*, p. 114.

of Upper Egypt was of rushes.¹ Petrie states that very thin grass was used for mats in the Hyksos period²: a large mat from El-Amârna was of palm fibre tied with hemp cords³ and another Eighteenth Dynasty mat was of papyrus.⁴ Winlock mentions grass mats of the Nineteenth Dynasty, the Twenty-sixth Dynasty and the sixth or seventh century A.D.,⁵ respectively, which latter 'were all made of halfa grass bundles on 5 mm. cords of the same grass usually, but sometimes of palm fibre.' Wainwright states⁶ that a mat of late New Kingdom date (Twenty-third to Twenty-fifth Dynasties) was made of soft rush. Winlock describes and illustrates⁵ 'two fundamental types of weaving in the ancient mats from Egypt,' and Mrs. Crowfoot describes and compares the ancient and modern methods of mat making.⁷

PAPYRUS

The papyrus plant (*Cyperus papyrus*), a plant belonging to the sedge family (which at one time grew abundantly in the marshy districts of Lower Egypt, where, however, it is no longer found, though it still flourishes in the Sudan), was employed by the Egyptians for many purposes, some of which have been enumerated by Herodotus,⁸ Theophrastus⁹ and Pliny¹⁰ and a few of which have already been described, but its principal value was for making sheets of material for writing upon, which was the forerunner of modern paper, to which it gave its name.

Specimens of papyrus from the Sudan measured by the author varied from seven feet to ten feet in length, excluding the flowering top and the root, and the maximum diameter was

¹ G. Brunton, *Qau and Badari I*, p. 71.

² W. M. Flinders Petrie, *Social Life in Ancient Egypt*, p. 143.

³ T. E. Peet and C. L. Woolley, *The City of Akhenaten*, I, p. 81.

⁴ J. E. Quibell, *The Tomb of Yuaa and Thuin*, in *Cat. Gén. du Musée du Caire*, p. 65.

⁵ H. E. Winlock and W. E. Crum, *op. cit.*, pp. 72-4.

⁶ G. A. Wainwright, (a) in *Heliopolis, Kafr Ammar and Shurafa*, W. M. Flinders Petrie and Others, p. 37; (b) *Bull. Soc. Sult. de Géog.*, IX, Cairo, p. 179.

⁷ G. M. Crowfoot, *The Mat Weaver from the Tomb of Khety*, in *Ancient Egypt*, 1933, pp. 93-9.

⁸ II, 37, 92, 96; VII, 25.

⁹ IV, 8, 3, 4.

¹⁰ XIII, 21-6; XXIV, 51.

nearly an inch and a half (1·4 inch).¹ The stem is triangular in section and consists of two parts only, a thin tough outer rind and an inner cellular pith, and it was this latter that was employed as a writing material. The method of making sheets suitable for writing upon from this very unpromising-looking material is described by Pliny,² according to whom the stem of the plant was sliced into thin strips, which were placed side by side upon a table and across them at right angles another series of similar stripes; they were then moistened with Nile water, pressed and dried in the sun, Pliny adding that Nile water 'when in a muddy state has the peculiar qualities of glue.' This account is both obscure and wrong. Thus there is no mention of whether the outer rind of the papyrus was removed or not before the material was sliced, though that it was removed is possibly to be inferred from a subsequent statement that the rind was 'solely used for making ropes.' Also, although the Nile water during flood is muddy, it does not contain anything that could possibly act as an adhesive. A later allusion to paste 'made of the finest flour of wheat mixed with boiling water' is far from clear, but probably refers to the fastening of a number of sheets of papyrus together to make one long sheet.³

Bruce⁴ 'made several pieces of this paper, both in Abyssinia and Egypt,' of which he says that 'some were excellent,' though this is qualified by the further statement that 'even the best of it was always thick and heavy, drying very soon, then turning firm and rigid and never white.' Bruce is as unsatisfactory as Pliny on the point of whether the rind was removed or not before the papyrus was sliced, though apparently not, since he says, 'There seemed to be an advantage in putting the inside of the pellicle in the situation in which it was before being divided, that is, the interior parts face to face, one long-ways and one cross-ways, after which a thin board of the cover of a book was laid first over it and a heap of stones piled upon it.' This was done, as expressly stated, 'while moist,' after which

¹ Kindly supplied by Mr. G. W. Grabham, Sudan Government Geologist.

² XIII, 21-6; XXIV, 51.

³ Pliny's account is described and criticized by D. de la Molle, in *Mémoire sur le papyrus et la fabrication du papier chez les anciens*, 1850.

⁴ J. Bruce, *Travels to Discover the Sources of the Nile*, 1805, VII, pp. 117-31.

'they were suffered to dry in the sun.' Bruce adds that it appeared to him 'that the sugar or sweetness, with which the whole juice of this plant is impregnated, is the matter that causes the adhesion of these strips together.'

The author tried to make papyrus paper by peeling off the rind, slicing the pith and strongly pressing the slices together, but was unsuccessful, because, as is now known, the papyrus was not fresh, but consisted of plants that had been sent to Cairo from the Sudan, the pith of which had become dry.

Battiscombe Gunn, who succeeded in making excellent papyrus paper,¹ from plants grown in his garden at Ma'adi, was good enough to demonstrate the method employed, as a result of which the author has been able to produce similar material. The method is to cut a number of sections of the fresh green papyrus stems into lengths that can easily be manipulated; strip off the outer rind; cut the inner pith into thick slices (not necessarily all of exactly the same thickness); place an absorbent cloth on a table and on this arrange a number of slices of the pith parallel to and slightly overlapping one another and across them at right angles a further lot, also slightly overlapping; cover with a thin absorbent cloth and beat the whole for an hour or two with a wooden mallet and finally place the material in a small press for several hours or over night. The slices become welded together, adhering firmly to one another and forming one homogeneous sheet of thin paper suitable for writing upon² the surface of which may be improved by burnishing. The colour of the paper produced, although almost white, was unfortunately marred by being spotted with numerous small light-brown coloured specks, which doubtless could be avoided if special precautions were taken. Any holes or thin places are easily patched before the sheet is pressed and dried by putting a small piece of fresh pith on the defective place and beating until it becomes merged into the rest.

The date when papyrus paper was first made is not known, but in the Cairo Museum there are small papyrus documents from both the Fifth and the Sixth Dynasties.³

¹ Now exhibited in the Cairo Museum.

² Without the addition of any extraneous adhesive.

³ Nos. 49623; 58043; 58063 and 58064.

WOVEN FABRICS

The woven fabrics, like most other objects that have survived from ancient Egypt, are those that have been found in tombs, and, since these are almost entirely confined to wrappings for the dead, and since, too, a particular kind of fabric, namely linen, was always employed for burial purposes unto a late date, it follows, first, that ordinary garments are generally absent, and second, that the nature of the fabric is not necessarily representative of that worn by the living. Occasionally, however, a garment, such as a shirt, is discovered on a body, or fabrics other than those on the body have also been placed in the tomb.

Spinning and weaving were among the oldest of the arts practised in ancient Egypt and woven fabrics from as early as the neolithic period¹ have been found. Both spinning and weaving are represented on the walls of several tombs of the Twelfth Dynasty at Beni Hasan^{2, 3} and El-Barsha⁴ respectively and also in an Eighteenth Dynasty tomb at Thebes⁵ and a model of Eleventh Dynasty date showing women engaged in spinning and weaving was found by Winlock at Thebes^{6, 7} and is now in the Cairo Museum.

Various aspects of spinning and weaving in ancient Egypt have been studied and described,^{8, 9, 10, 11} one article (Mrs. Crowfoot's) dealing with the similarities between the ancient and modern methods. The yarn was spun by hand (chiefly by

¹ G. Caton-Thompson, *The Neolithic Industry of the Northern Fayum Desert*, in *Journal Royal Anthropol. Inst.*, LVI (1926), p. 315.

² P. E. Newberry, *Beni Hasan*, I, Pl. XXIX; II, Pl. XIII.

³ F. Ll. Griffith, *Beni Hasan*, IV, Pl. XV.

⁴ P. E. Newberry, *El Bersheb*, I, Pl. XXVI.

⁵ N. de G. Davies, *Five Theban Tombs*, Pl. XXXVII.

⁶ H. E. Winlock, *The Egyptian Expedition, 1918-1920*, in *Bull. Met. Mus. of Art, New York*, II (1920), p. 22.

⁷ H. Ling Roth; G. M. Crowfoot, *Models of Egyptian Looms*, in *Ancient Egypt*, 1921, pp. 97-101.

⁸ H. E. Winlock, *Heddle-Jacks of Looms*, in *Ancient Egypt*, 1922, pp. 71-4.

⁹ A. C. Mace, *Loom Weights in Egypt*, in *Ancient Egypt*, 1922, pp. 75-6.

¹⁰ G. Crowfoot, (a) *Hand Spinning in Modern Egypt*, in *Ancient Egypt*, 1928, pp. 110-17; (b) *Methods of Hand Spinning in Egypt and the Sudan*, in *Bankfield Museum Notes, Second Series*, 1931.

¹¹ W. M. Flinders Petrie, *Kahun, Gurob and Hawara*, pp. 27-8.

women) on a small spindle that dangled by the thread that was being twisted. The loom was a hand one and was horizontal until the Hyksos invasion, when a vertical loom was introduced.

Distaffs,¹ spindles, spindle whorls and loom weights have been often found.

The only kind of woven fabrics found in Egyptian tombs until a late date are those of linen, since wool, although probably always used for clothing to at least some extent and certainly at a late date, was accounted ceremonially unclean and so, as Herodotus, referring to the Egyptians, said² 'nothing of wool is brought into temples, or buried with them; that is forbidden.' At a very late period the knowledge, first of cotton and then of silk, reached Egypt. All of these materials may now separately be described.

Linen

Flax (originally *Linum humile*, but now *Linum usitatissimum*) has been grown in Egypt from very early times, since linen fabrics have been found of neolithic,³ Badarian⁴ and predynastic^{5,6} dates respectively, and there is still a considerable flax cultivation in the country. The commercial side of flax growing in Egypt is referred to by Pliny, who states⁷ that 'by its aid . . . she imports the merchandise of Arabia and India' and that it was from Egyptian flax that 'the greatest profits are derived.'

The old Egyptian linen varies considerably in texture, from the finest gauze to a canvas-like coarseness. The nature and quality of the weaving have been investigated by various experts, notably, J. Thomson⁸; W. W. Midgley⁹; T. Midgley¹⁰;

¹ Wilkinson (J. G. Wilkinson, *The Ancient Egyptians*, 1890, II, 87-8) confuses the distaff with the spindle.

² II, 81.

³ G. Caton-Thompson, *op. cit.*, p. 315.

⁴ G. Brunton and G. Caton-Thompson, *op. cit.*, pp. 64-7.

⁵ G. Brunton, *Qau and Badari I*, pp. 70-1.

⁶ W. M. Flinders Petrie, *Prehistoric Egypt*, p. 47. ⁷ XIX, 2.

⁸ Lond. and Edin. Phil. Mag. 5, 1834. Quoted at great length by Wilkinson (*The Ancient Egyptians*, II (1890), pp. 75-9).

⁹ (a) In *Historical Studies*, Brit. School of Arch. in Egypt, pp. 37-9; (b) In *Heliopolis, Kafr Ammar and Shurafa*, W. M. Flinders Petrie and E. Mackay, pp. 48-51.

¹⁰ (a) In *The Badarian Civilization*, G. Brunton and G. Caton-Thompson, pp. 64-7; (b) In *Qau and Badari I*, G. Brunton, pp. 70-1.

T. W. Fox¹; W. G. Thomson² and A. F. Kendrick,³ T. Midgley says, 'The structure of textile fabrics of the earlier dynastic period in Egypt is now fairly well understood, and the character of the loom and its accessories equally well known. . . . From the tomb paintings . . . we have learnt how the flax stem was treated to obtain the bast fibres, how these were cleansed, heckled, roved, spun and warped. Finally, we have in these pictures the breast and warp beams shown pegged to the ground, lease rods and heddles inserted, and the weaving of cloth from these carefully prepared yarns. No reed was used, so that . . . there is a great irregularity in the spacing of the warp threads as compared with modern fabrics; . . . Apart from this, it is singular how little within the range of plain weaving which is known to-day was not practised by the weavers of the Old Kingdom. . . . Thus at the very dawn of the historic period in Egypt we find the craft of the spinner and the weaver very highly developed in technique; manifestly the early stages of the evolution of the loom must be sought far back in the predynastic era.'

A few small fragments of tapestry-woven linen fabric were found in the tomb of Tuthmosis IV⁴ and a number in the tomb of Tut-ankhamûn, including 'an archer's gauntlet, tapestry woven in coloured threads'⁵; a 'pair of gloves . . . of tapestry woven linen'⁶; 'robes . . . decorated with patterns in coloured linen threads. Some of these are examples of tapestry weaving . . . but there were also undoubted cases of applied needlework'⁷; two garments, which 'In their pristine state . . . must have been gorgeous pieces of colour. They take the form of a long loose vestment, having richly ornamented tapestry-woven decoration with fringes on both sides. In addition to this ornamentation, one of them has needlework of palmette pattern, desert flora and animals, over the broad hem at the bottom.'⁸

¹ In *The Tomb of Two Brothers*, M. A. Murray, pp. 65-9.

² In *The Tomb of Thoutmôsis IV*, H. Carter and P. E. Newberry, pp. 143-4.

³ *Catalogue of Textiles from Burying-Grounds in Egypt*, I, II, III.

⁴ H. Carter and P. E. Newberry, *The Tomb of Thoutmôsis IV*, pp. 143-4.

⁵ H. Carter and A. C. Mace, *The Tomb of Tut-ankh-Amen*, I, p. 171.

⁶ H. Carter, *The Tomb of Tut-ankh-Amen*, III, p. 126.

⁷ H. Carter and A. C. Mace, *op. cit.*, p. 172.

⁸ H. Carter, *op. cit.*, II, pp. 124-5.

In the Cairo Museum there are three specimens of pleated linen of the XVIIIth dynasty, one 'showing two series of accordion-pleatings at right angles to each other being specially remarkable.'¹

Wool

Although there are very few instances of wool having been found in Egyptian tombs until a late date, there cannot be any doubt that the Egyptians, who possessed large flocks of sheep, made use of wool as a covering. Herodotus mentions the wearing of loose, white woollen mantles over linen tunics² and Diodorus states that the Egyptian sheep yielded wool 'for clothing and ornament.'³

Woollen garments have been found in graves of the early Christian period,^{4, 5, 6, 7} and the use of coloured wool at this date for the decoration of linen fabrics is fairly common. The few finds of wool of earlier dates that can be traced are, in chronological order, as follows, namely one predynastic example of 'brown and white woollen knitted stuff'⁸; one specimen found in the pyramid of Mycerinus at Giza, recorded as 'part of a skeleton . . . enveloped in coarse woollen cloth of a yellow colour,'⁹ which was almost certainly an intruded burial of much later date than the pyramid; one specimen from the Twelfth Dynasty found by Petrie,¹⁰ who says regarding it, 'wool was also spun; a handful of weaver's waste is mainly made up of blue worsted ends and blue wool, with some red and some green ends. A lump of red dyed wool, not yet spun, was found'; a woollen netted turban of pre-Christian Roman date,¹¹

¹ The Egyptian Museum, Cairo, *A Brief Description of the Principal Monuments*, 1932, p. 98 (No. 6094).

² II, 81.

³ I, 6.

⁴ G. A. Reisner, *Arch. Survey of Nubia, Report for 1907-1908*, I, p. 107.

⁵ C. M. Firth, *Arch. Survey of Nubia, Report for 1908-1909*, pp. 36, 91, 96.

⁶ C. M. Firth, *Report for 1910-1911*, pp. 98, 124, 190.

⁷ G. Brunton, *Qau and Badari III*, p. 26.

⁸ W. M. Flinders Petrie and J. E. Quibell, *Naqada and Ballas*, p. 24.

⁹ H. Vyse, *The Pyramids of Gizeh*, II, p. 86.

¹⁰ W. M. Flinders Petrie, *Kahun, Gurob and Hawara*, p. 28.

¹¹ H. E. Winlock, *The Egyptian Expedition 1924-1925*, in *Bull. Met. Mus. of Art, New York*, II (1926), pp. 31-2.

with reference to which, Winlock, the finder, says, ' Apparently it was the style in Thebes just before the Christian era to swathe the hair in fine linen veils until the head was twice its natural size, and then over that to pull such a netted brown and red turban, tied behind with drawing-strings.'

Cotton

The home of the cotton industry is undoubtedly India, from which it spread westwards.

Schoff states¹ that ' Cotton thread and cloth are repeatedly mentioned in the laws of Manu, 800 B.C.'

Herodotus (fifth century B.C.) states that in India ' there grows on wild trees wool more beautiful and excellent than the wool of sheep; these trees supply the Indians with clothing.'² Also ' The Indians wore garments of tree-wool.'³

On an Assyrian cylinder of the time of Sennacherib (seventh century B.C.) ' trees that bear wool ' are mentioned.⁴

Theophrastus (fourth to third century B.C.) states that the island of Tylos (i.e. Bahrein) in the Arabian (i.e. Persian) Gulf ' produces the wool-bearing tree in abundance ' and refers to fabrics being woven from it⁵: he also says that ' This tree is also found in India as well as in Arabia.' Pliny (first century A.D.) copies this description of cotton from Theophrastus, but contrasts the trees that bear ' wool ' (cotton) with those that bear ' Seres ' (i.e. mulberry trees with silk cocoons on them).⁶

Respecting the date either of the first use, or of the first manufacture, of cotton fabrics in Egypt nothing certain is known, but the systematic cultivation of cotton in the country only dates back to the early part of the nineteenth century.

No record can be traced of cotton fabrics having been found in Egypt even as late as the end of the Roman period, though Reisner discovered cotton textiles of Graeco-Roman date at Meroe in the Sudan.⁷

¹ W. H. Schoff, *The Periplus of the Erythraen Sea*, p. 71.

² III, 106.

³ VII, 65.

⁴ L. W. King, in *Proc. Soc. Biblical Arch.*, XXXI (1909), pp. 339-43.

⁵ *Enquiry into Plants*, IV, 7, 7, 8.

⁶ XII, 21.

⁷ R. E. Massey, *A Note on the Early History of Cotton*, in *Sudan Notes and Records*, VI (1923), pp. 231-3.

Herodotus (fifth century B.C.) relates that two linen corslets given by the Egyptian king Amasis of the Twenty-sixth Dynasty (about 569 to 525 B.C.), one to the Samians or Lacedaemonians and the other to a temple in Lindus, were embroidered in cotton.¹

Pliny (first century A.D.) states that 'The upper part of Egypt, in the vicinity of Arabia, produces a shrub known by the name of *gossypium*'² and that 'the most esteemed vestments worn by the priests of Egypt are made of it.'² This same author also says that 'Ethiopia, which borders Egypt, has in general no remarkable trees with the exception of the wool-bearing ones . . .'³ Pliny, however, is by no means a paragon of detailed accuracy.

Silk

The silk industry had its origin in China and probably the material first reached the Mediterranean countries by way of Persia. Silk was not used in Egypt until late and the earliest reference to its use that can be traced is that of Lucanus (middle of first century A.D.), who describing Cleopatra says 'her white breasts resplendent through the Sidonian fabric, which, wrought in close texture by the skill of the Seres, the needle of the workman of the Nile has separated, and has loosened the warp by stretching out the web.'⁴ A portion of a coloured silk fabric has recently been found at Kostol, south of Abu Simbel, the exact date of which is not yet certain though probably not earlier than the fourth century A.D.⁵ This, which was examined by the author, was not a mulberry silk (i.e. the fibres were not those of the caterpillar *Bombyx mori*) but a 'wild silk' of the nature of Tussah silk. A blue and red coloured silk border to a garment of Roman date was found by Brunton in Upper Egypt.⁶ From the fourth century A.D. onwards silk becomes more common.

¹ III, 47.

² XIX, 2.

³ XIII, 28.

⁴ *Pharsalia*, x, 141, quoted by W. H. Schoff, *op. cit.*, p. 265.

⁵ Found by Mr. W. B. Emery: not yet published.

⁶ G. Brunton, *Qau and Badari III*, p. 26.

Ramie

Midgley reports ramie fibre in a fabric of predynastic date,¹ but the copy of the photomicrograph published is far from convincing and that the material was indeed ramie needs confirmation, more particularly as ramie fibre is a native of China and therefore most improbable in Egypt at that early date.

¹ W. W. Midgley, in *Heliopolis, Kafr Ammar and Shuraфра*, W. M. Flinders Petrie and E. Mackay, p. 50; Pl. LVIII.

ADDENDUM

An important article on the early use of cotton in Egypt has been published while this book was passing through the press, namely, F. Ll. Griffith and Mrs. G. K. Crowfoot, *On the Early Use of Cotton in the Nile Valley*, in *Journal of Egyptian Archaeology*, xx (1934), pp. 5-12.

CHAPTER VII

METALS AND MINERALS

The principal metals employed in ancient Egypt were copper, gold, iron, lead, silver and tin, but one instance of the use of antimony and one of platinum are known.

Three alloys were also employed, namely, bronze, which is essentially an alloy of copper and tin; electrum, an alloy of gold and silver, and, at a very late date, brass, which is an alloy of copper and zinc. In addition to these metals and alloys, a number of ores and natural mineral substances were also used.

These metals, alloys, ores and minerals will now be described.

ANTIMONY

In view of the numerous erroneous statements that antimony was commonly employed in ancient Egypt, it becomes necessary to explain very clearly what antimony is. It is a bright, silver-white brittle metal, frequently having a crystalline structure, that is largely used at the present day for making certain alloys, such as type metals, Britannia metals and anti-friction metals. Although antimony occurs naturally in the free state as metal, this condition is extremely rare and it is generally found only in small amount, the antimony employed in industry being produced artificially from certain naturally-occurring compounds (ores). So far as is known, neither antimony nor antimony ores occur in Egypt, but probably traces of antimony compounds, though not recorded, are present in the local copper and lead ores and a trace has been found in the nickel ore from St. John's island in the Red Sea.¹

Antimony ores are found in many parts of the world that

¹ F. W. Moon, *Prelim. Geol. Rpt. on Saint John's Island*, p. 16.

have no connexion with ancient Egypt, but they also occur in countries that were in contact with Egypt, for instance they are plentiful in Asia Minor and occur also in Persia and, in small amount, in certain of the Greek islands (Mytilene and Chios).

Only one instance of the use of metallic antimony and very few instances of the use of antimony compounds in ancient Egypt can be traced. The former consists of some small beads from the Twenty-second Dynasty (945 to 745 B.C.) found by Petrie at El-Lâhûn ¹, ² and, as the production of the metal from its ore at that date is most improbable, since the process was not known in Europe until about the fifteenth or sixteenth century A.D., it is almost certain that the beads were made from native metal, but whether this was brought to Egypt as metal or already fashioned into beads cannot, of course, be stated.

The only other instances of the use of metallic antimony in antiquity of which any record can be found, are two mentioned by Dr. Gladstone, who says, ² 'M. Oppert indeed found at Khorsabad a tablet of metallic antimony and M. Sarzec found at Tello part of a vase of pure antimony.' The vase from Tello mentioned is the same as the 'Chaldean vase' referred to by Berthelot, ³, ⁴

The instances of the use of antimony compounds in ancient Egypt that can be traced are (a) a Nineteenth Dynasty eye-paint consisting of antimony sulphide ⁵; (b) an eye-paint (undated) which consisted of the sulphides of lead and antimony, ⁶ the relative proportions of the two not having been determined, though it is highly probable that the material was essentially galena (sulphide of lead) containing only a small proportion of sulphide of antimony as a natural impurity and (c) three other

¹ W. M. Flinders Petrie, *Illahun, Kabun and Gurob*, p. 25; Pl. XXIX (56).

² J. H. Gladstone, *On Metallic Copper, Tin and Antimony from Ancient Egypt*, in *Proc. Bibl. Arch.*, xxiv (1891-2), pp. 223-7.

³ *Comptes rendus*, civ (1887), p. 265, quoted by H. C. and L. H. Hoover, in their translation of Agricola's *De re Metallica*, p. 429, n. 57.

⁴ J. W. Mellor, *Inorganic and Theoretical Chemistry*, ix, p. 339.

⁵ A. Wiedermann, *Varieties of Ancient Kohl*, in *Medum*, W. M. Flinders Petrie, p. 43.

⁶ J. Barthoux, *Les fards, pommades et couleurs dans l'antiquité*, in *Congrès Int. de Géog.*, Le Caire, 1925, iv (1926), p. 254.

specimens of eye-paint, which contained traces of an antimony compound as an accidental impurity.¹ The general idea, therefore, that the ancient Egyptian eye-paint (other than the green malachite) consisted of, or contained, antimony or an antimony compound is wrong and there is no justification for calling it antimony; *stibium* (an early name for sulphide of antimony, transferred later to the metal); sulphide of antimony, or other name implying such composition. The misunderstanding has probably arisen from the fact that antimony compounds were employed as eye cosmetics and eye medicines by the Greeks² and Romans³ and hence all eye-paints that had a similar dark-grey or black appearance were assumed to have the same composition, whereas the ancient Egyptian eye-paint, apart from the green malachite, consisted of galena (sulphide of lead) sometimes containing traces of sulphide of antimony as a natural impurity, with such occasional substitutes as black oxide of copper, black oxide of iron and black oxide of manganese.¹

In addition to the very rare use of an antimony compound as an eye-paint (possibly only one and at the most two examples being known), a compound of antimony and lead has been found as the colouring matter of yellow glass of the Nineteenth Dynasty, Persian period and Arab period respectively,⁴ and traces of antimony occur in sundry ancient Egyptian copper and bronze objects, having been derived from an impurity in the copper ore.

In order, if possible, to prevent the perpetuation of mistakes and also to avoid being taken to task for ignoring several recently published statements asserting that antimony was used in ancient Egypt, the author feels obliged, though very reluctantly, to explain why these instances are not included with those enumerated. Three of the most recent of such statements will, therefore, be discussed, namely:

1. Dr. Howard Carter, referring to certain docketts on the lids of three boxes from the tomb of Tut-ankhamûn, says that these docketts, which give a list of the contents of the boxes (missing when the boxes were found), mention antimony among

¹ See p. 81.

² Dioscorides, *De materia medica*, v, 59.

³ Pliny, xxxiii, 33, 34.

⁴ See p. 125.

other objects and he adds, 'We found . . . antimony powder . . . dispersed on the floor of the chamber.'¹

The inscriptions are in hieratic characters and only in two instances are they now legible, one inscription being masked by the paraffin wax used to coat the box.² Of the two inscriptions left, one³ mentions only incense and gum (probably odoriferous gum-resin being meant) and the other⁴ refers to various articles, among which were two objects 'to serve for the putting on of *msdmt*,'⁵ which is the word for eye-paint usually translated as antimony. The author ventures to say, however, that it does not mean antimony, and he doubts very much whether the Egyptians of that date (if ever) had a special word for metallic antimony, which until comparatively recently was a very rare metal, since its natural occurrence is so limited that it cannot have been well known until it was produced artificially from its ores, which was not earlier than about the fifteenth century A.D. It may be mentioned, too, that the bright, light-grey coloured gritty material obtained by powdering metallic antimony would be very unsuitable as an eye-paint, and Dioscorides⁶ and Pliny⁷ (both first century A.D.), who refer to its use, but who unfortunately are far from clear, seem to state that the antimony was not employed in the metallic condition as found, but that it was roasted, which would have converted it into the oxide. But even if it be assumed that when *msdmt* is translated antimony it means, not metallic antimony, but an antimony compound, in view of what has been proved respecting the composition of the Egyptian eye-paints, it is equally improbable that it should have any such meaning.

The 'antimony powder' stated to have been found in the tomb of Tut-ankhamûn, if the expression be taken literally, means metallic antimony in a finely divided condition. But, considering the scarcity of metallic antimony anciently, the

¹ Howard Carter, *op. cit.*, III, p. 119.

² The inscription can probably be rendered legible either by the removal of the wax, or by photography, using ultra-violet or infra-red rays.

³ Museum Guide, No. 1036.

⁴ Museum Guide, No. 899.

⁵ Kindly translated for the author by Dr. J. Cerný.

⁶ *Op. cit.*, V, 59.

⁷ XXXIII, 33, 34.

occurrence of such a material is so very improbable that nothing less than a chemical analysis would be sufficient to establish its identity. Even if the word antimony is used loosely to mean an antimony compound, such as the sulphide or oxide, which are the only two antimony compounds at all likely to have been known at the time, the appearance of these is so little characteristic that again a chemical analysis would be necessary for identification. It is suggested that a confusion has arisen between sulphide of lead (galena), the principal use of which in ancient Egypt was as an eye-paint (and small lumps of which were found in the tomb and are now in the Cairo Museum) and sulphide of antimony.¹ The author would like to mention, too, that he had the privilege of working with Dr. Carter at Luxor during eight seasons and that he saw and handled most of the objects from the tomb and that, as a chemist, he is perfectly familiar with the appearance of metallic antimony and with the tests for antimony and antimony compounds and that nothing that was either one or the other came under his notice.

2. Mr. H. Gauthier, in a recent *History of Egypt*, says with reference to a scene in a tomb of Middle Kingdom date at Beni Hasan 'en particulier la poudre d'antimoine très recherchée par les Égyptiens . . . comme fard pour les yeux.'² Here it is not a matter of a material whose identity could be fixed by chemical analysis, but a question of translation, and all that has just been said on this subject is equally applicable in this case.

3. Messrs. Fink and Kopp state that antimony plating was known in Egypt in about the Fifth or Sixth Dynasty.^{3, 4} The evidence adduced consists of a copper ewer and basin of that date on the former of which are smooth bright areas of 'considerable size' looking like silver and on the latter small scat-

¹ Garstang (J. Garstang, *Burial Customs of Ancient Egypt*, p. 114) almost certainly makes a similar mistake when he says that 'fragments of antimony ore were found.'

² H. Gauthier, *L'Égypte pharaonique*, in *Précis de l'histoire d'Égypte*, I, p. 100.

³ C. G. Fink and A. H. Kopp, *Ancient Egyptian Antimony Plating on Copper Objects*, in *Metropolitan Museum Studies*, IV (1933), pp. 163-7.

⁴ C. G. Fink, *Chemistry and Art*, in (a) *Industrial and Engineering Chemistry*, 26 (1934), p. 236, and (b) *Chemistry and Industry*, 53 (1934), pp. 216-20.

tered spots having the same silvery appearance, which when tested proved to be a thin layer of metallic antimony. The tests applied are given and there seems no doubt that the white metal is indeed antimony.

The possibility of the antimony having been derived from the copper is considered by Fink and Kopp and rejected, because (1) they were unable to find antimony in the copper; (2) they have never heard of a case of decuprification of the surface of a copper-antimony alloy and (3) a smooth bright deposit of antimony could never result from such a process. Hence they consider that the antimony plating was applied intentionally to simulate silver and two methods are suggested in which this might have been done, one using antimony sulphide and natron and the other oxide of antimony, 5 per cent acetic acid (equivalent to vinegar) and strips of iron, materials which it is stated 'are known to have been available in ancient Egypt.' These various arguments may now be considered.

1. That antimony was not found in the copper. Unfortunately neither the number of specimens of the copper tested, nor the method of testing are given. Naturally every possible care had to be taken to avoid disfiguring the objects and, therefore, large samples were impossible, but unless a number of samples were taken from different parts of the objects and unless these were tested by some very delicate method, such as the spectroscopic one, a small percentage of antimony might easily have been missed.

Antimony is not a very uncommon impurity in ancient Egyptian copper objects, and that it has not been found more frequently is probably largely owing to the fact that generally no search for it is made. However, it is recorded as present as a trace in a middle predynastic copper axe-head¹; in two copper objects of the Fourth Dynasty²; in a copper object from the Twelfth Dynasty in which there was 0.2 per cent³ and in another copper object, possibly from the same period

¹ H. C. H. Carpenter, in *Nature*, 130 (1932), pp. 625-6.

² J. H. Gladstone, *On Metallic Copper, Tin and Antimony from Ancient Egypt*, in *Proc. Soc. Bibl. Arch.*, xiv (1892), pp. 223-7.

³ J. H. Gladstone, *On Copper and Bronze of Ancient Egypt and Assyria*, in *Proc. Soc. Bibl. Arch.*, xii (1890), pp. 227-34.

in which there was 0.7 per cent¹ and in a further, undated but probably early, copper object in which there was a trace.²

2. That decuprification of the surface of a copper-antimony alloy is unlikely. If by this is meant the corroding away of the copper from the attacked surface of a copper object containing antimony, in such a manner as to leave the antimony, it is admitted that this is most improbable and that the antimony should be left as a thin, bright metallic layer is believed to be impossible.

That the ewer and basin had not only been corroded, but probably corroded to a considerable extent, is proved by the fact that they had been cleaned and that chemical, mechanical and electrolytic methods of cleaning had all been necessary. The effect of such corrosion must have been the destruction of the original surface, with the formation of the usual products found on corroded copper objects from Egypt, namely, chiefly copper oxide and basic carbonate, with possibly some basic chloride, and, if it be assumed that the copper contained a small proportion of antimony as an impurity, which is neither impossible nor unlikely, this latter would probably have been converted into oxide. Then came the cleaning. This is stated to have been done partly by means of alternating baths of dilute alkaline and acid solutions, the loosened material being removed with wooden instruments or brushes, and partly by an electrolytic alkaline treatment. But, if the corroded surface contained oxide of antimony, as suggested, and if the electrolytic treatment was that advocated by Fink and Eldridge,³ as appears very probable, then iron anodes would have been employed and all the conditions necessary to produce a thin coating of metallic antimony on the copper would have been present, and this antimony layer would have been deposited in much the same manner as is suggested by Fink and Kopp was done anciently (except that it would have been in an alkaline and not in an acid solution), namely by means of iron. The improbability

¹ G. B. Phillips, *The Composition of some Ancient Bronzes*, in *Ancient Egypt*, 1924, p. 89.

² M. Berthelot, in *Recherches sur les origines de l'Égypte*, J. de Morgan, I, pp. 223-9.

³ C. G. Fink and C. H. Eldridge, *The Restoration of Ancient Bronzes and other Alloys*, pp. 15-17.

that the ancient Egyptians at any period, particularly at so early a date as that of the ewer and basin, knew antimony plating is so great that very much stronger evidence than that cited is necessary before it can be accepted as a proved fact, and the author believes that the patches and spots of plating found were the result of the process of cleaning employed, and that they were brought about by the reduction of oxide of antimony (or other antimony compound present in the corroded surface of the copper) to the metallic state.¹

Fink and Kopp state that 'Antimony sulphide has been found in ancient specimens of *Kohl* . . . and antimony oxide is readily derived therefrom by roasting.' So far as is known, only one specimen of *kohl* (and that of a date from 1,100 to 1,500 years after that of the ewer and basin) has been found that consisted of sulphide of antimony; one other specimen may have contained a substantial proportion of sulphide of antimony, but it is more probable that it contained only a very small amount, and a few others contained traces. But, even if a few specimens of *kohl* of the necessary date did consist of sulphide of antimony (which is not probable and for which there is no proof), it would require considerable evidence to establish as a fact that some of this *kohl* was converted into oxide of antimony by roasting and that the oxide so obtained was then employed for plating a ewer and basin. It is most improbable, too, that strips of iron should have been employed in the Fifth or Sixth Dynasty. Even if iron were generally known, which was not the case, that it should have been used in the manner suggested is very unlikely.

COPPER, BRONZE AND BRASS ²

Copper

Copper, which, unlike gold, is not usually found in nature in the metallic condition, but which must generally be produced

¹ The chief form of plating known to the ancient Egyptians was that of hammering thin sheets of one metal on to another. See gold plating (p. 189) and silver plating (p. 207).

² Parts of this section have been taken from two articles published by the author in *The Journal of Egyptian Archaeology*, namely (a) *Copper in Ancient Egypt*, XIII (1927), and (b) *Notes on the Early History of Tin and Bronze*, XIV (1928).

from unattractive-looking ores, was yet one of the earliest metals known to man. In Egypt it was employed before gold as far back as Badarian and early predynastic times.

The earliest copper objects found are beads, borers and pins, which date from the Badarian period¹ and which continued in use during the early predynastic period, supplemented however by bracelets, small chisels, finger rings, harpoon heads, small implements, needles, tweezers and other small articles.²⁻⁸ 'All the objects previous to the middle predynastic are rare, small and flimsy,'^{9, 10} but, by the end of the predynastic period, the Egyptians 'were in possession of practical copper weapons'⁹ and during the early dynastic period 'heavy practical axe-heads, adzes, chisels, knives, daggers, spears, implements and ornaments'⁹ as well as household utensils, such as ewers and basins, were in use in considerable numbers.

It is sometimes stated that during the earlier periods when copper was used in comparatively small amount, it was obtained from native metal (i.e. copper found naturally in the metallic state), but however this may be which will be discussed later, there cannot be any doubt that in all subsequent periods it was derived entirely from the smelting of ores. The copper chisel of early dynastic date analysed by Professor C. O. Bannister and quoted by Professor C. H. Desch, which contained 2.51 per cent of silver and 4.14 per cent of gold, of which Desch

¹ G. Brunton and G. Caton-Thompson, *The Badarian Civilization*, pp. 7, 27, 33, 41.

² G. Brunton and G. Caton-Thompson, *op. cit.*, pp. 56, 60, 71.

³ E. R. Ayrton and W. L. S. Loat, *Predynastic Cemetery at El Mahasna*, pp. 18, 19, 21, 32, 33.

⁴ W. M. Flinders Petrie, *Diospolis Parva*, p. 24.

⁵ D. Randall-MacIver and A. C. Mace, *El Amrah and Abydos*, pp. 16, 18, 20, 21, 23, 24.

⁶ W. M. Flinders Petrie and J. E. Quibell, *Naqada and Ballas*, pp. 14, 20-4, 27-9, 45, 47, 48, 54.

⁷ W. M. Flinders Petrie, *Prehistoric Egypt*, pp. 25, 26, 47.

⁸ W. M. Flinders Petrie, *Tools and Weapons*.

⁹ G. A. Reisner, *Early Dynastic Cemeteries of Nag-ed-Der*, I, pp. 127, 128, 134.

¹⁰ Brunton found a large copper axe-head weighing three and a half pounds of the middle predynastic period (H. C. H. Carpenter, in *Nature*, 130 (1932), pp. 625-6).

says,¹ 'The composition of this specimen, with the high proportion of silver and gold, suggests that it is composed of native metal,' was supplied by the author, who received it from the late Mr. C. M. Firth, who found it in Nubia. It is most unlikely that such a comparatively large object as the chisel in question and of the period to which it is dated, should have been made out of native copper and a very much more probable explanation is that the copper ore used had contained small proportions of gold and silver,² a phenomenon not unknown in the eastern desert, whence the copper ore was probably derived. Thus Ball states³ that in the south-eastern desert 'Besides gold some of the quartz veins contain copper,' and the Dungash gold mine (situated east of Edfu) also contains veins of copper ore.⁴

Rickard says⁵ that 'native copper is far more abundantly distributed than is generally supposed' and that 'The use of native copper marks the beginning of every ancient metal culture.' That copper is found native in various parts of the world and that in certain localities, especially in North America, it occurs in abundance and that at one time this copper was largely used for making ornaments, weapons and tools, is well known, but the people who employed it never seem on their own initiative to have got beyond its use and never to have proceeded to the smelting of copper ores. That native copper was ever found and used in Egypt lacks proof, and though some few of the earliest copper objects, the Badarian beads for example, *may* have been made from native copper, that they were so made is by no means certain, and such statements as the following go beyond the proved facts: 'The predynastic graves of Egypt . . . contain beads of native copper . . .'⁶; 'in the Badarian graves of the Fayûm there is native copper . . .'⁷ and 'Traces of copper, chiefly pins, needles and bodkins hammered out of

¹ C. H. Desch, *Report on the Metallurgical Examination of Specimens for the Sumerian Committee of the British Association*, in *Report of the British Association*, 1928.

² All Egyptian gold contains silver.

³ J. Ball, *The Geog. and Geol. of South-Eastern Egypt*, p. 353.

⁴ See p. 161. ⁵ T. A. Rickard, *Man and Metals*, I, pp. 105, 106, 108.

⁶ T. A. Rickard, *op. cit.*, I, p. 96.

⁷ T. A. Rickard, *The Early Use of the Metals*, in *Journal Inst. Metals*, XLIII (1930), p. 305.

native metal are found in the debris of the earliest agricultural settlements of the Nile Valley.'¹

In any discussion of the question whether or not native copper was employed in Egypt there is one very important fact to be taken into account, namely, the use as eye-paint of considerable quantities of an ore of copper (malachite) that occurs in the country; that is easily converted into copper; that can be proved to have been employed later as a source of copper, and the use of which can be traced as far back as the use of copper and possibly even farther and, therefore, the conditions in Egypt were particularly favourable for the early discovery of copper by smelting the ore, and there is no need to postulate the occurrence and use of the native metal.

Copper ores occur within the geographical limits of modern Egypt in two widely separated localities, namely, in Sinai and in the eastern desert. The amount of ore, however, is not sufficiently large to warrant mining at the present day, since copper ores may be obtained in much greater quantity and in more easily accessible places elsewhere.

The evidence for ancient copper mining and smelting by the Egyptians is twofold, first, the existence of ancient mines with ruins of mining settlements and ancient slag heaps, and second, inscriptions in the neighbourhood of mines left by mining expeditions.

Sinai

Ancient workings, some of which are of considerable size, which admittedly were either for copper ore or for turquoise, exist at Maghârah and at Serâbît el-Khâdim, both of which are situated in the south-west of the peninsula of Sinai and about twelve miles apart.²⁻⁶

¹ E. A. Marples, *The Copper Axe, in Ancient Egypt*, 1929, p. 97.

² J. de Morgan, *Recherches sur les origines de l'Égypte*, pp. 216-39.

³ W. M. Flinders Petrie, *Researches in Sinai*, pp. 18, 19, 27, 46-53, 154-62.

⁴ J. Ball, *The Geog. and Geol. of West-Central Sinai*, pp. 11, 13, 163, 188, 190, 191.

⁵ T. Barron, *The Topog. and Geol. of the Pen. of Sinai (Western Portion)*, pp. 40-5, 166-9, 206-12.

⁶ Mines and Quarries Department, Egypt, *Report on the Mineral Industry of Egypt*, 1922, pp. 36, 38.

That some of these workings were not for copper ore, but for turquoise (which was employed for beads and jewellery in both the Old and Middle Kingdoms and even as early as the Badarian period),¹ there can be no doubt, since at both places turquoise is still found and at Maghârah turquoise mining is carried on by the local bedouin at the present day, the main workings extending for about two kilometres on the west side of the valley.^{2, 3, 4} At Serâbât el-Khâdim, although turquoise occurs, it is only found at the present time in small quantity and is not now worked.²⁻⁵

In addition to turquoise, however, copper ore also was undoubtedly mined anciently at Maghârah, since ruins of mining settlements exist, dating principally from the Old Kingdom, but also from the Middle Kingdom, in the former of which have been found 'a great amount of copper slag and waste scraps from smelting; also some chips of copper ore, many broken crucibles and part of a mould for an ingot,'⁶ and in the latter 'a great quantity of copper slag, scraps from smelting, pieces of crucibles, charcoal and, in one case, part of a crucible-charge of crushed ore not yet reduced,'⁷ also a mould (undated) for casting the blades of weapons.⁸

At Serâbât el-Khâdim the proof of ancient copper mining is less evident, as the workings have not been carefully examined from this point of view, but copper ore occurs in the immediate neighbourhood and a crucible for melting copper was found in the temple.⁹

The copper ore mined anciently, both at Maghârah and at Serâbât el-Khâdim, was largely the green carbonate (malachite), with a little blue carbonate (azurite) and a little silicate (chrysocolla), only small quantities of any of which now remain.^{10, 11, 12}

¹ See p. 166, n. 4, and also p. 353.

² Petrie, *ibid.*

³ Barron, *ibid.*

⁴ Mines and Quarries Dept., *ibid.*

⁵ Ball, *ibid.*

⁶ W. M. Flinders Petrie, *op. cit.*, p. 51.

⁷ W. M. Flinders Petrie, *op. cit.*, p. 52.

⁸ J. de Morgan, *op. cit.*, I, p. 229.

⁹ W. M. Flinders Petrie, *op. cit.*, p. 162.

¹⁰ J. de Morgan, *op. cit.*, pp. 216-39.

¹¹ J. Ball, *op. cit.*, pp. 188, 191.

¹² T. Barron, *op. cit.*, pp. 166, 208.

The inscriptions left by the mining expeditions were ¹ at Maghârah; in the valley and mines near Serâbât el-Khâdim; in the temple at Serâbât el-Khâdim and the approach to it and in the Wâdi Nasb.^{2, 3}

At Maghârah there were ¹ 45 records, consisting of 36 inscriptions on the rocks, 8 graffiti and one stela, which began in the First Dynasty (1 inscription) and were continued in the Third Dynasty (3 inscriptions); Fourth Dynasty (3 inscriptions); Fifth Dynasty (8 inscriptions); Sixth Dynasty (2 inscriptions); Twelfth Dynasty (13 inscriptions); Eighteenth Dynasty (1 inscription) and Nineteenth Dynasty (1 inscription), with also 5 inscriptions of the Old Kingdom and 8 of the Middle Kingdom that cannot be assigned to any particular dynasty.

In the valley and mines near Serâbât el-Khâdim there were ¹ 15 records, (10 from mines and one possibly from a mine) consisting of 13 inscriptions on the rocks and 2 stelae. They were of the Twelfth Dynasty (10 inscriptions) and Eighteenth Dynasty (3 inscriptions) with one of the Middle Kingdom of which the dynasty cannot be recognized and one of doubtful date.

In the temple and its approach there were ¹ 288 inscriptions, principally on loose blocks of stone, statuettes, free-standing stelae and other objects, but including a number of inscriptions on walls and pillars. These consisted of one inscription with the name of Sneferu (which is almost certainly of later date than the reign of this Pharaoh and probably not earlier than the Middle Kingdom) together with the following named: Twelfth Dynasty (72 inscriptions); Eighteenth Dynasty (75 certain inscriptions and 11 less certain); Nineteenth Dynasty (30 inscriptions); and Twentieth Dynasty (22 inscriptions); also 38 certain inscriptions and 4 less certain of the Middle Kingdom; 18 certain inscriptions and 2 less certain of the Nineteenth to Twentieth Dynasties and 15 inscriptions of which the dates were altogether doubtful.

¹ The word is employed in the past tense as many of the inscriptions have either been destroyed or removed.

² J. H. Breasted, *Ancient Records of Egypt*, v (Index), pp. 102, 95.

³ A. H. Gardiner and T. E. Peet, *The Inscriptions of Sinai*, 1, pp. 7-16.

In the Wâdi Nasb there was one inscription on the rock of the Twelfth Dynasty.

The inscriptions in those instances where there was any reference to the nature of the activities undertaken, frequently made mention of turquoise¹ and once of copper, but they were very unsatisfactory for use as a history of Egyptian copper mining. Thus the earlier ones (First, Third, Fourth and beginning of Fifth Dynasties respectively) merely recorded the names and titles of the Pharaohs, then reference to the leaders and officers of the expeditions were included (Fifth Dynasty) and at later dates statements of the objects of the expeditions. Although there can be little doubt that all the expeditions were for the purpose of mining either copper ore or turquoise, there is no direct proof of this from the inscriptions themselves in the case of the earlier ones, which might have been merely punitive expeditions, though they are believed to have been more.

In addition to the workings at Maghârah and at Serâbât el-Khâdim, already mentioned, ancient workings for copper ore exist at the following-named places in the neighbourhood of Serâbât el-Khâdim :

1. Gebel (mount) Um Rinna, situated N.N.W. of Serâbât el-Khâdim, where there is an excavation some 20 metres wide, one to two metres high and about 50 metres long. The ore extracted was malachite, traces of which still remain.²

2. Wâdi (valley) Malha. These workings are close to Gebel Um Rinna, Wâdi Malha draining the eastern flank of the mountain. The ore mined was malachite, small quantities of which still exist.³

3. Wâdi (valley) Khârig, called Wâdi Halliq by Barron. This is situated to the west of the northern portion of Wâdi Nasb. Here there is an excavation about 100 metres long, 10 metres wide and two metres in average height. The ore extracted was malachite, which has been practically exhausted.^{4, 5}

In the south-east of the peninsula ancient workings for

¹ The word used is *mafkat*, which Breasted translates as malachite; see p. 354.

² J. Ball, *op. cit.*, p. 188.

³ T. Barron, *op. cit.*, p. 166.

⁴ T. Barron, *op. cit.*, pp. 167, 206.

⁵ J. Ball, *op. cit.*, pp. 190, 191.

copper ore and ancient slag heaps exist in several places, namely :

1. Near the plain of Senned. The working here is in the nature of a dyke, which has been excavated for nearly two miles and is 'exceedingly rich' in the blue carbonate (azurite).¹

2. In the hills west of the Nebk-Sherm plain. Some of the ore is malachite, and possibly this alone was worked anciently, but chrysocolla also exists, a deposit having been found by modern prospectors at Wâdi Samra (sometimes called Wâdi Samara).¹

3. Near Wâdi Ramthi, one of the feeders of Wâdi Nasb, which enters the Gulf of Aqaba at Dahab.²

In addition to the slag heaps situated at some of the mines, which have already been mentioned, there are also a number of others where there are not any mines, the largest of which is in Wâdi Nasb (called Wâdi Nasib by Ball), which is situated north-west of Serâbât el-Khâdim. In this wâdi, as already stated, there is an inscription of the Twelfth Dynasty. In continuation of this heap there is much scattered slag all the way up the path to the stela of Amenemmes IV.³⁻⁶

Similar, but smaller, ancient slag heaps exist at the south side of Sêh Baba (the lower part of Wâdi Nasb), which is situated to the south-west of Serâbât el-Khâdim.⁷

Another ancient slag heap is at Gebel (mount) Safariat south of Gebel Hebrân.⁸

Also in east Sinai, though not on Egyptian territory, but a short distance beyond the Palestine boundary, on the west side of the drainage line of Wâdi Araba and near the caravan route, there are ancient workings for copper ore and also ancient slag heaps showing that the ore was smelted at the mine. The ore

¹ W. F. Hume, *The Topog. and Geol. of the Pen. of Sinai (South-Eastern Portion)*, pp. 118, 119.

² Kindly communicated by Dr. Ball.

³ W. M. Flinders Petrie, *Researches in Sinai*, p. 27.

⁴ J. Ball, *op. cit.*, p. 13.

⁵ T. Barron, *op. cit.*, pp. 44, 208.

⁶ T. A. Rickard, *Man and Metals*, I, pp. 196-7.

⁷ W. M. Flinders Petrie, *op. cit.*, pp. 18-19.

⁸ T. Barron, *op. cit.*, p. 208.

is malachite and azurite.¹ Similar ore to this particular occurrence was found by Menghin and Amer at Maadi.²

Eastern Desert

Copper ore exists in a number of localities in the eastern desert, namely :

1. In Wâdi (valley) Araba, which is situated almost due east of Beni Suef (about Lat. 29° N.), near the Gulf of Suez. A specimen of ore examined by the author was chrysocolla: the amount of ore is only small and there is no evidence that it was mined anciently.³

2. At Gebel (mount) Atawi, which is situated a little south of the latitude of Luxor, but nearer the Red Sea than the Nile. There are ancient workings, but the nature of the ore is not stated.³

3. At Gebel (mount) Dara (approx. Lat. 28° N. ; Long. 33° E.), where there are ancient workings. The ore is chrysocolla.^{3, 4, 5}

4. In the Dungash gold mine, which is situated east of Edfu (approx. Lat. $24^{\circ} 50'$ N. ; Long. $33^{\circ} 45'$ E.). The nature of the ore is not stated, nor whether it was worked anciently: the amount of ore is probably very small.³

5. Among the low hills south of Wâdi (valley) Gemâl (Lat. $24^{\circ} 35'$ N. ; Long. $34^{\circ} 50'$ E.). The ore is malachite, but it is not stated whether there are ancient workings.^{3, 6}

6. At Hamish. (Lat. $24^{\circ} 32'$ N. ; Long. slightly E. of 34°). There are old workings with three main shafts. The ore is chalcopyrite (sulphides of copper and iron). The sides of one shaft are encrusted with blue copper compounds formed from the pyrites.⁷

¹ Information kindly supplied by Mr. R. H. Greaves, formerly Controller, Mines and Quarries Department, Egypt.

² O. Menghin and M. Amer, *The Excavations of the Egyptian University in the Neolithic Site at Maadi*, p. 48.

³ W. F. Hume, *Explan. Notes to Geol. Map of Egypt*, p. 37.

⁴ T. Barron and W. F. Hume, *Top. and Geol. of the Eastern Desert of Egypt, Central Portion*, pp. 33, 259.

⁵ J. Wells, *Report of the Dept. of Mines*, 1906, p. 34.

⁶ W. F. Hume, *A Prelim. Report on the Geol. of the Eastern Desert of Egypt*, pp. 41, 56.

⁷ Dr. J. Ball, private communication.

7. At Abu Seyâl (sometimes wrongly called Absciel) in Lat. $22^{\circ} 47' N$. Wells reported that the ore occurred in the form of pyrrhotite (iron pyrites) associated with copper pyrites (copper sulphide),¹ but, although there may be copper pyrites at some distance below the surface, the ore exposed is chrysocolla. The mine was worked 'extensively' in ancient times and some at least of the ore was smelted at the mine, as there are remains of ancient furnaces and slag.

8. At Um Samiuki at the foot of Gebel (Mount) Abu Hamâmîd, about 50 kilometres from the coast north-west of Ras Benas, there are extensive ancient workings with several shafts. At the surface, the ore is malachite and azurite, of which there is a thickness of about seven metres and below this are copper and zinc sulphides and lead ore (the zinc sulphide containing silver). There are also ore crushers, pottery (possibly broken crucibles) and slag.²

In addition to the ancient slag heaps, already mentioned, situated at the various mines, there is also one where there are no mines, namely at Kubbân on the east bank of the Nile opposite Dakka (Lat. $23^{\circ} 10' N$).^{3, 4} The origin of the ore smelted is not certain, though it is often assumed to have been that from the Abu Seyal mine, part of which at least, however, was smelted at the mine, as the remains of ancient furnaces and slag attest.

Quality of Ore

Very few analyses of Egyptian copper ore have been made and the only ones that can be traced are as follows :

Sinai. (a) South-western mines. This ore yields from 5 to 15 per cent of copper according to Rickard⁵ and up to 18 per cent according to Rüppell.⁶ (b) South-eastern mines. A specimen of ore analysed by Professor Desch gave 3 per cent of copper.⁷

¹ J. Wells, *op. cit.*, p. 34.

² Kindly communicated by Dr. W. F. Hume and Dr. H. Sadek Bey.

³ J. Ball, *The Geog. and Geol. of South-Eastern Egypt*, p. 353.

⁴ C. M. Firth, *The Arch. Survey of Nubia, Report for 1908-1909*, p. 24.

⁵ T. A. Rickard, *op. cit.*, p. 196.

⁶ E. Rüppell, *Reisen in Nubien, Kordofan und dem petraïschen Arabien*, p. 266.

⁷ Result kindly supplied by Mr. G. A. Garfitt, Hon. Sec. Sumerian Committee, British Association.

Eastern Desert. (a) From Wâdi Araba two specimens of ore analysed by the Chemical Department, Cairo, gave 36 and 49 per cent of copper respectively.¹ (b) It is stated that the Abu Seyal ore yields on an average well over 3 per cent of copper and that in places it is very rich and may give as much as 20 per cent.² (c) A specimen of ore from the Abu Hamamîd mine gave 13 per cent of copper.³

Amount of Ore

Some evidence of the amount of ore dealt with anciently in certain districts may be obtained from the dimensions of the ancient slag heaps, but the data are very incomplete, and, even if it be assumed that all the heaps exist and are known, which is almost certainly not the case, many of them have neither been measured nor examined. The various slag heaps that are known have already been mentioned; but the only ones of which any particulars are given are those of Wâdi Nasb, Sêh Baba and Kubbân, which may now be considered.

Slag Heap at Wâdi Nasb. The dimensions of this given by Petrie in 1906 are 500 feet long, 300 feet wide and 6 or 8 feet high.⁴ Petrie, however, quotes Bauerman (an English geologist who explored the district in 1868), for very different dimensions, namely 250 yards by 200 yards,⁴ while another writer gives Bauerman's dimensions as being 350 yards by 250 yards by 8 or 10 feet.⁵ Bauerman's own statement,⁶ however, is that the slag forms a roughly elliptical heap, about 350 yards long and 200 yards in breadth, the depth being very variable and probably not more than 8 to 10 feet at the most, but that over the greater part of the area the slag forms only a thin coating on the rock. Mr. G. W. Murray of the Desert Surveys of Egypt, who measured the slag in 1929, found two heaps: '(1) An area roughly 230×110 metres, with an average depth of

¹ Figures kindly supplied by Dr. W. F. Hume.

² J. Wells, *Report of the Dept. of Mines*, 1906, p. 34.

³ Kindly communicated by Mr. R. S. Jenkins, Insp. Dept. Mines and Quarries.

⁴ W. M. Flinders Petrie, *op. cit.*, p. 27.

⁵ Anon., *The Copper of Sinai*, in *Mining and Scientific Press*, Sept. 1919, pp. 429-30.

⁶ H. Bauerman, *Quart. Journal Geological Society*, xxv (1869), p. 29.

1 metre ; (2) an area of 100×60 metres, very irregular, but very thin.¹

Petrie's estimate for the amount of slag present is 100,000 tons, but Rickard, taking Bauerman's measurements, makes the amount only 50,000 tons,² which seems much too small for the dimensions given (which are in yards for the length and breadth and not in feet, as is the case with Petrie's measurements) and if an average depth of only two feet be allowed the result would be 118,000 tons.

In order to arrive at the weight of the slag it is necessary to know, not only the measurements of the heap, but also the specific gravity of the material, and this does not seem to have been determined, but only guessed. In the absence of specimens of the Wâdi Nasb slag, the author determined the specific gravity of five specimens of similar copper slag from Sêh Baba, which were found to vary from 3.1 to 3.5, with a mean of 3.36, and this will be assumed to be approximately correct also for the Wâdi Nasb slag. On this basis the calculated weight of the slag is as follows :

(a) From Petrie's dimensions, 98,000 tons, which is very close to Petrie's own estimate of 100,000 tons.

(b) From Bauerman's dimensions, probably not less than 100,000 tons, since with an average depth of only two feet the amount would be 118,000 tons.

(c) From Murray's dimensions about 90,000 tons.

Rickard states that the slag contains 2.75 per cent of copper,³ which on 100,000 tons of slag represents 2,750 tons of copper : he assumes this to be one-third the copper content of the ore and therefore that two-thirds of the copper, or 5,500 tons, were extracted.⁴

¹ G. W. Murray, Private letter dated Nov. 22nd, 1932.

² T. A. Rickard, *Copper and Gold Mines of the Ancient Egyptians*, in *Eng. and Mining Journal-Press*, June 20th, 1925, p. 1006.

³ A specimen of slag, probably that from Wâdi Nasb, analysed by Sebelien (*Ancient Egypt*, 1924, p. 10) contained 21.65 per cent of copper. This slag, however, is not of uniform composition and contains metallic copper, both in large pieces and in coarse grains and, unless properly sampled by a competent person, an analysis of an isolated specimen is likely to be misleading. Mr. G. W. Murray informed the author that one specimen analysed gave 2.3 per cent of copper.

⁴ T. A. Rickard, *Man and Metals*, I, pp. 196-7.

Slag Heap at Sêh Baba. The dimensions of one heap as given by Petrie are 80 feet by 60 feet,¹ but another estimate is 50 feet by 50 feet by 1 foot.² Greaves, however, states that both these estimates are too high for the slag now present, but he also says that the heap is gradually being washed away.³ The specific gravity of the slag, as already stated, is 3.36. The weight of the slag, therefore, from the dimensions given, would be either 450 tons or 235 tons, according to which estimate be taken, and the amount of copper extracted, represented by this slag, would be either 25 or 13 tons.

Slag Heap at Kubbân. This heap is 105 feet long and 13 feet broad,⁴ but the height cannot easily be measured on account of the accumulated sand. Let it be assumed to be 2 feet. The specific gravity of the two specimens determined by the author was 2.9. The total amount of slag, therefore, is 220 tons and, if the amount of copper in the original ore and the proportion extracted be assumed to have been the same as for Sinai, this heap will represent about 12 tons of copper.

On the evidence of the slag heap at Wâdi Nasb, the minimum amount of metallic copper yielded anciently by the Sinai mines up to the date of this heap (Twelfth Dynasty), amounted to a minimum of 5,500 tons, though probably more. This must be supplemented by the amount smelted at Maghârah, Sêh Baba, Gebel Safariat, the plain of Senned and the hill region of the extreme south-east, which together was probably considerable, though except for a portion of that from Sêh Baba, no estimate is possible. To the copper from Sinai must be added that extracted from the mines of the eastern desert, for which the only basis for an estimate is the slag heap at Kubbân, which certainly represents only a small fraction of the total ore smelted.

In any consideration of the total amount of copper yielded by the Egyptian mines and whether or not it could have been sufficient for the needs of the country until about the Eighteenth

¹ W. M. Flinders Petrie, *op. cit.*, p. 18.

² By Mr. R. S. Jenkins, Insp. Dept. Mines and Quarries. Private communication.

³ Mr. R. H. Greaves, formerly Controller Dept. of Mines and Quarries. Private communication.

⁴ Kindly measured for the author by Tewfiq Effendi Boulos, Chief Inspector Dept. of Antiquities, Upper Egypt, who also supplied specimens.

Dynasty, when admittedly copper was imported from Asia, it should not be forgotten that Egypt was then, as it still is, a comparatively small agricultural country where the greater proportion of the people did not use copper and more than 5,200 years after the first use of copper in Egypt, namely in the year 1800 A.D., or only 134 years ago, when copper was employed for many more purposes and very much more extensively than in ancient Egypt, the entire world's production only amounted to 10,000 tons.¹ In relation to the amount of copper used in ancient Egypt, the product of the Sinai and eastern desert mines must have been considerable and de Morgan's criticism that the quantity of ore from Sinai (he does not appear to have known of the eastern desert supply) was 'insignificant'² and that 'Egypt must be ruled out absolutely from among the copper-producing countries'² may be disregarded. Although Lepsius did mistake the manganese ore capping some of the Sinai peaks for copper slag (he writes of 'great slag-hills'³ and 'artificial mounds' 'covered with a massive crest of slag')³ this in no way either destroys or lessens the value of the facts respecting the number and extent of the ancient workings for copper ore and the ancient slag heaps that have been enumerated.

Date of earliest Mining

Owing to the fact that copper ore and turquoise were both mined at the only two localities in Sinai where inscriptions have been found, namely at Maghârah and Serâbât el-Khâdim, and that both materials were used at an equally early date⁴ (as was also metallic copper) there is no certainty whether the earliest inscriptions refer to copper ore or to turquoise. That during the Old Kingdom some at least of the mining at Maghârah was for copper ore is proved by the finding of mining settlements of that date with copper ore, crucibles, copper slag, waste scraps from smelting and an ingot mould.⁵ The fact,

¹ R. Allen, *Copper Ores*, p. 1.

² J. de Morgan, *Prehistoric Man*, p. 114.

³ R. Lepsius, *Discoveries in Egypt, Ethiopia and the Peninsula of Sinai*, p. 348.

⁴ Copper ore (malachite); metallic copper and turquoise were all used in the Badarian period (G. Brunton and C. Caton-Thompson, *The Badarian Civilisation*, pp. 27, 41, 56). Mr. Brunton has informed the author that the doubtful material has now been definitely identified as turquoise.

⁵ W. M. Flinders Petrie, *op. cit.*, p. 51.

too, that a copper axe-head of middle predynastic date¹ and also the copper of which certain metal bands of First or Second Dynasty date² were composed contained manganese, is a very strong indication that the original copper ore had been obtained from the neighbourhood of the manganese ore deposits in Sinai, that is probably from Maghârah, and, if so, then the Sinai ore was being smelted for copper as early as the middle predynastic period.

So far as is known there are not any inscriptions in the eastern desert relating to copper mining, and the sole evidence at present of any date in connexion with this mining is that furnished by the slag heap at Kubbân, the fort there having certainly been occupied during the Empire, but not earlier than the Twelfth Dynasty.^{3, 4} It should be noted that in the enumeration of tribute taken by the Egyptians at various times from the peoples who dwelt to the south, there is no mention whatever of copper, thus suggesting that the copper mining in the eastern desert was always in the hands of the Egyptians and not of the Nubians. Strabo possibly refers to the eastern desert of Egypt when, in describing Ethiopia, he says that 'There are also mines of copper, iron and gold'⁵ and Diodorus has practically the same statement, namely, 'It is said there are in it (i.e. in Ethiopia) mines of gold, silver, iron and brass . . .',⁶ but the geography of this time was very vague and southern Ethiopia, which was in the Sudan, or even the Sudan generally, where such mines exist, may have been meant, rather than the northern part of Ethiopia, which was in Egypt.

The earliest references to the importation of copper into Egypt from abroad (excluding Sinai) are of the Eighteenth Dynasty in which, as also in the following dynasty (Nineteenth Dynasty), copper was received from Retenu⁷ and Zahi⁸ in Syria; from Arrapachitis⁹ in western Asia (the exact locality

¹ See n. 10, p. 154.

² W. M. Flinders Petrie, *The Royal Tombs of the Earliest Dynasties*, II, p. 40.

³ C. M. Firth, *The Arch. Survey of Nubia, Report for 1909-10*, p. 5.

⁴ A. E. P. Weigall, *A Guide to the Antiquities of Upper Egypt*, 1910, pp. 525-7.

⁵ xvii, 2, 2.

⁶ I, 3.

⁷ J. H. Breasted, *op. cit.*, II, 447, 471, 491, 509, 790.

⁸ II, 459, 460, 462, 490.

⁹ II, 512.

of which is unknown), from Asia¹; from God's Land² (a name used to designate several different and widely separated places, including countries in western Asia, the eastern desert of Egypt and Punt); and from Isy³ (which is often stated to mean Cyprus, but which Wainwright has shown not to be Cyprus, but a country situated on the coast of north Syria.⁴)

Copper Ores

The copper ores found in Egypt (including Sinai) are principally azurite, chrysocolla, malachite and sulphide, whose occurrence has already been dealt with in connexion with the ancient mines, but which may now be considered in greater detail.

Azurite is a beautiful deep blue basic carbonate of copper that occurs in copper deposits and is found both in Sinai and in the eastern desert: being an oxidized product derived from the decomposition of copper sulphide, azurite always occurs at or near the surface and hence is easily found and worked: it does not occur in any great amount and is not nearly so plentiful as malachite, with which it is generally associated. Azurite was employed anciently in Egypt both as a source of metallic copper and as a pigment,⁵ until for the latter purpose it was displaced by an artificial blue frit.

Chrysocolla is a blue or bluish-green ore of copper that chemically consists of the silicate: it occurs both in Sinai and in the eastern desert of Egypt, in both of which places it appears to have been worked anciently to a small extent as a source of metallic copper. Apart from this use of the ore and from its occasional employment as an eye-paint,⁶ only one example of chrysocolla from ancient Egypt can be traced, namely, fashioned into a small figure of a child that was found in a predynastic grave at Hierakonopolis.^{7, 8}

Malachite, the ancient Egyptian name of which was *shesmet*,

¹ J. H. Breasted, *op. cit.*, II, 45, 104, 175, 614, 755; III, 217, 537, 910.

² II, 274.

³ II, 493, 511, 521.

⁴ G. A. Wainwright, *Alashia = Alasa; and Asy*, in *Klio, Beitrage zur alten Geschichte*, 1913. (Original paging not given in reprint.)

⁵ See p. 283.

⁶ See p. 81.

⁷ J. E. Quibell and W. F. Green, *Hierakonopolis*, II, p. 38.

⁸ J. E. Quibell and W. M. Flinders Petrie, *Hierakonopolis*, I, p. 7.

is a green basic carbonate of copper that was the principal and earliest ore of copper used anciently, because, like azurite, it is an oxidized product derived from the decomposition of copper sulphide, and therefore is the ore found on the surface of most copper ore deposits: it occurs in Egypt both in Sinai and in the eastern desert, from one or both of which places the early supply was derived.

The use of malachite in Egypt goes back to the Badarian period, from which time onwards, until at least the Nineteenth Dynasty, it was employed as an eye-paint¹: it was used, too, at an early date as a pigment for mural painting² and for other purposes, including the very important one of colouring glaze and glass,³ and very occasionally also for making beads, amulets⁴ and other small objects; but the principal value of malachite in Egypt was as a source of metallic copper, and it is the richest in copper of all the ores.

Copper Mining

Copper ores, principally malachite, were almost certainly obtained at first and for a long period, entirely from surface deposits without any attempt at underground mining. For extracting the ore nothing more elaborate than crude stone (flint) tools would have been required; but for cutting shafts at a later date, to follow the vein of ore underground, copper chisels were undoubtedly employed and suitable chisels existed from the late predynastic period onwards. In the Sinai mines Petrie found evidence of the use of copper chisels only, and not of stone tools for cutting the rock.⁵

Copper Smelting

After the ore had been mined it was probably crushed and hand picked and then smelted.

At the present day copper is obtained from its ores by means of an elaborate series of complicated metallurgical operations conducted in special furnaces, the exact nature of the operation and the type of furnace used depending upon the kind of ore dealt with. It is not proposed to describe these methods, but

¹ See p. 79.

² See p. 287.

³ See p. 122.

⁴ See p. 349.

⁵ W. M. Flinders Petrie, *op. cit.*, pp. 48-9, 61, 161.

the treatment in its simplest form of the oxidized class of ores, to which malachite belongs, may be mentioned. It consists in mixing the ore with coke and suitable fluxes and heating in a furnace provided with a blast. The ancient Egyptian substitute for this operation was to mix the broken ore with charcoal in a heap on the ground, or in a shallow pit, and to apply a simple form of forced draught by means either of blowpipes (which were used certainly as early as the Fifth Dynasty since they are depicted on the wall in the tomb of Ti at Saqqâra)¹ or of bellows (which apparently were not known until about the Eighteenth Dynasty, at which period they are shown in the tomb of Rekhmara² and in that of Menkheperasonb Amenmose,³ both at Thebes). Since copper melts at $1,083^{\circ}\text{C}$. this is not an impossible temperature to have been obtained with the primitive methods suggested, if only a small quantity of ore were operated upon at one time.

When the smelting was finished, the unburnt and partly burned fuel would probably have been removed, so as to allow the metal to cool, which would then have been broken up into smaller pieces for use, this possibly having been done when it had just become solid, at which stage copper is peculiarly brittle and easily broken up by hammering.⁴ Gowland states that this method of treating copper still survived in Korea in 1884.⁵

As pointed out by Rickard,⁶ the primitive method of smelting practised must have resulted in 'a spongy mass of metal, incompletely fused and containing extraneous matter.'

Copper Working

In order to shape the pieces of crude copper obtained by breaking up the mass (never very large) from the furnace and to fit them for use, they would necessarily have been hammered, since it would soon be discovered that copper was fairly soft

¹ G. Steindorff, *Das Grab des Ti*, Pl. 134.

² P. E. Newberry, *The Life of Rekhmara*, Pl. XVIII.

³ N. and N. de G. Davies, *The Tomb of Menkheperasonb Amenmose and Another*, Pl. XII.

⁴ T. A. Rickard, *op. cit.*, p. 117.

⁵ W. Gowland, *The Metals in Antiquity*, in *Journal Royal Anthrop. Inst.*, XLII (1912), p. 241.

⁶ T. A. Rickard, *op. cit.*, p. 116.

and malleable, and this hammering would have consolidated the metal and would have freed it from some of the grosser impurities. As there were no such appliances at an early date as special tongs for holding hot metal, all the hammering at first was necessarily done cold, which has frequently been proved from the microscopical examination of ancient copper objects.

At a later period it was discovered that copper could be shaped more quickly and more easily by melting it and pouring it into moulds while liquid, the moulds being open ones. Petrie states¹ that they were 'cut out of a thick piece of pottery and lined smooth with fine clay and ash,' which seems unnecessarily complicated, since it would have been much simpler to have impressed the shape of a previously made object in wet clay and then dried and baked it, when it would have become a pottery mould. Stone moulds were also employed, a possible example being the one found in Sinai by de Morgan.² The crucibles used for melting the copper were of clay and a large number, generally broken, have been found at mining centres: a specimen discovered by Petrie in Sinai is described and illustrated by him.³ The earliest evidence of casting known to the author is that of an axe-head of middle predynastic date found by Brunton and examined by Sir Harold Carpenter, who concludes 'that it was cast roughly to shape, and then either cold-hammered and annealed or hammered while hot.'⁴

When the cast object was a dagger, knife or chisel, the cutting edge would naturally have been hammered to thin and shape it, and this hammering would have hardened the metal considerably, a fact that could hardly have escaped notice long. If hammered too much, however, copper becomes brittle, which would also soon have been observed and avoided, since it is not likely that the remedy for brittleness would have been discovered until much later. This remedy is to heat the copper to a temperature of from about 500° C. to 700° C. for a short time, the process being known as annealing or tempering, the

¹ W. M. Flinders Petrie, *The Arts and Crafts of Ancient Egypt*, 1910, p. 100.

² J. de Morgan, *op. cit.*, I, p. 229.

³ W. M. Flinders Petrie, *Researches in Sinai*, p. 162; Pl. 161.

⁴ H. C. H. Carpenter, *An Egyptian Axe Head of Great Antiquity*, in *Nature*, 130 (1932), pp. 625-6.

tempering of copper being the softening and not hardening, as is sometimes wrongly stated. The only secret of hardening copper the ancient Egyptians knew was to hammer it, and the 'lost art' that is so often referred to is a myth. In an experiment made by Desch it was shown that copper with an initial hardness (Brinell scale) of 87 was raised to a hardness of 135 by hammering.¹

The Egyptians became very expert at an early date in the art of working copper, perhaps the most remarkable examples of this being the large statue of Pepi I (Sixth Dynasty) and the accompanying small statue, which are the oldest Egyptian metal statues known,² one of them being also the largest. The metal of which these statues consist is often stated to be bronze, on the strength of an analysis quoted by Maspero³ (who disregards it and calls the metal copper), which was made by Professor Mosso of Rome and shows 6.6 per cent of tin. There is, however, considerable probability that some confusion of samples occurred and that the specimen examined was not from the statues. The material was also analysed by Dr. Gladstone,⁴ who reported that the presence of tin was doubtful. The author analysed a sample, taken by himself from the larger statue, and found the metal to be copper free from tin, and since then Professor Desch has published a detailed analysis showing 98.2 per cent of copper and no tin.⁵ With respect to these statues it has never been definitely established whether they have been hammered to shape or cast, both opinions having been expressed, but the evidence seems to be in favour of hammering.

As excellent early examples of small copper objects, the ewer and basin found by Reisner in the tomb of Queen Hetepheres⁶

¹ C. H. Desch, *The Tempering of Copper*, in *Discovery*, VIII (1927).

² 'The Pepi statues were not the most ancient of their kind in Egypt. The Palermo stone records the making of a copper statue of Khasekhemui (beginning of Third Dynasty),' H. R. Hall, *The Art of Egypt through the Ages*, edited by Sir E. Denison Ross, p. 17.

³ G. Maspero, *Guide to the Cairo Museum*, English trans., 1910, p. 73.

⁴ J. H. Gladstone, in *Dendereh*, W. M. Flinders Petrie, pp. 61-2.

⁵ C. H. Desch, *Report on the Metallurgical Exam. of Specimens for the Sumerian Committee of the British Association*, in *Report of the British Assocn.*, 1928.

⁶ G. A. Reisner, *The Tomb of Hetep-heres*, in *Bull. Mus. of Fine Arts (Special Number)*, Boston, xxv (1927), p. 31.

(Fourth Dynasty) may be mentioned. The basin and body of the ewer have been hammered to shape, but the spout of the ewer has been cast and inserted, probably being fixed merely by cold hammering, since welding, brazing and the use of soft solder were not discovered until much later. Petrie mentions other similar ewers and basins from royal tombs made in the same manner.¹

Although soft solder was not known until late there is an example of hard solder used for joining copper in the tomb of Hetepheres. When the author was cleaning the cylindrical copper sockets in which the upright poles of the canopy rested (which are made of sheet copper formed into a cylinder with the two ends of the copper overlapping where they meet), a thin silver-white metallic layer was noticed on both sides of the joints and between the two layers of copper. This on testing was found to consist largely, if not wholly, of silver, though the presence of a small proportion of copper cannot be entirely excluded, and it had manifestly been used as solder. The plating of copper both with silver,² of which one example is known, and gold,³ of which there are numerous instances, was also practised.

From the analyses of ancient copper objects,⁴ it is evident that (as is only to be expected) the copper employed was never pure, but always contained small proportions of other ingredients, the most common of which were antimony, arsenic, bismuth, iron, manganese, nickel and tin, the total impurities generally amounting to less than 1 per cent, though occasionally they were more. These impurities were all derived accidentally from the ore employed, and, with the exception of the bismuth, which would be deleterious, they would all harden the copper.

Statements are sometimes made with reference to the impurities in copper such as that 'Various small amounts of alloys were used to harden it, probably by mixing ores for reduction; bismuth, manganese, arsenic and tin are thus found used,'⁵ and 'Down to this age copper was used with only small amounts of hardening mixture.'⁶ These statements, attributing to

¹ W. M. Flinders Petrie, *The Arts and Crafts of Ancient Egypt*, p. 99.

² See p. 207.

³ See p. 189.

⁴ See pp. 424-5.

⁵ W. M. Flinders Petrie, *Social Life in Ancient Egypt*, pp. 149-50.

⁶ W. M. Flinders Petrie, *The Arts and Crafts of Ancient Egypt*, 1910, p. 100.

intention what was merely the result of natural conditions, are not only contrary to all probability, but are entirely unsupported by evidence. The only constituent added intentionally to copper in Egypt was at first tin, which produced bronze and, at a later period, lead, which made the bronze easier to cast.

Bronze

The word bronze as used to-day has a wide meaning, and includes a number of different alloys consisting wholly or largely of copper and tin, but in some cases containing also small proportions of other ingredients, among which zinc, phosphorus and aluminium may be mentioned. Early bronze, however, was much simpler and consisted only of copper and tin, with traces of such other ingredients as happened to be present in the raw materials employed. At a later date, as already mentioned, an addition of lead was sometimes made, but such an admixture although of the bronze class, is not a typical or normal bronze. At the present day, ordinary bronze contains about 9 to 10 per cent of tin, but ancient bronze is more variable, the proportion of tin ranging from about 2 per cent to about 16 per cent. Tin in less proportion than about 2 per cent is generally due to the presence of a small amount of tin oxide in the copper ore, and it would be misleading to consider such a mixture to be bronze, since the production of the artificially-made alloy marks a definite stage in the history of early civilization that it is convenient and desirable to keep separate from the still earlier stage when the only metal employed was copper, although this copper was sometimes impure and might contain a trace of tin.

The advantages of bronze over copper are (a) that by the addition of small proportions of tin, up to about 4 per cent, the strength and hardness of copper is increased, particularly when hammered, though as much as 5 per cent of tin produces an alloy that becomes brittle when hammered, unless frequently annealed during the process.¹ At what date the danger of too much tin and the remedy of annealing for an overdose were discovered is not known; (b) that an addition of tin lowers the melting point of copper (copper, m.p. $1,083^{\circ}$ C. : copper

¹ T. A. Rickard, *op. cit.*, pp. 131, 134.

95 per cent, tin 5 per cent, m.p. $1,050^{\circ}\text{C.}$: copper 90 per cent, tin 10 per cent, m.p. $1,005^{\circ}\text{C.}$: copper 85 per cent, tin 15 per cent, m.p. 960°C.)¹ ; (c) that tin 'notably increases the liquidity of the melt, thereby facilitating casting operations. Here we have the chief advantage of converting copper into bronze. Copper is a bad metal for casting, not only because it contracts on cooling . . . but on account of its tendency to absorb gases and to become porous thereby. The presence of tin checks the absorption of oxygen and other gases.'²

The early history of bronze is obscure, but one fact is certain, namely, that it was not discovered in Egypt, since not only is tin ore absent, but bronze was used in western Asia a considerable time before it reached Egypt. Although claims have been made for both Europe and Africa, there is no doubt that bronze was an Asiatic discovery³ and it has been found at Ur as early as about 3500 B.C. to 3200 B.C.^{4, 5} and the knowledge of it must have spread from Asia to Egypt and later to Europe. Although used so early at Ur, bronze cannot have originated in southern Mesopotamia, since this country contains no metallic ores.

The simplest assumption to make with regard to the discovery of bronze is that it was an accident, and there are only four possible ways in which it could have happened, namely, first, by fusing together metallic copper and metallic tin ; second, by smelting a mixture of copper ore and metallic tin ; third, by smelting the naturally-occurring combined mineral of copper and tin (stannite) ; and fourth, by smelting either a naturally-occurring or artificially-made mixture of copper ore and tin ore. The first two methods are out of the question, unless tin was known before bronze, and all the evidence available points to a later knowledge. The third method is most improbable, not only because the combined copper-tin mineral, stannite,

¹ J. W. Mellor, *Inorganic and Theoretical Chemistry*, VII, p. 355.

² T. A. Rickard, *op. cit.*, p. 132.

³ This subject will be considered further in connexion with tin ; see p. 212.

⁴ C. H. Desch, *Report on the Metallurgical Examination of Specimens for the Sumerian Committee of the British Association*, in *British Association Report for 1928*, pp. 437-41.

⁵ H. J. Plenderleith, in *Ur Excavations, II, The Royal Cemetery*, C. L. Woolley, p. 290.

occurs only in small quantities and in a few localities and because, if it had ever been employed, it could never have led either to the use of the principal and only important ore (cassiterite), for the use of which at a later period there is ample proof, or to the production of metallic tin, but also because the resulting bronze would have contained a much larger proportion of tin and more sulphur than is found in early bronze. In one locality in China a lode of stannite is worked at the present day. 'The metal obtained on smelting . . . contains 42.57 per cent of tin, 49.7 of copper, 1.3 of sulphur and 1.8 of lead.'¹ Desch says,² too, that 'The analyses of the early bronzes offer no support for the suggestion that they were obtained accidentally by smelting minerals which contain both copper and tin. Such minerals are always of a complex character, and would not give rise to such pure alloys as the early bronzes are found to be. It would appear, therefore, that these bronzes have been made by mixing oxide ores of copper and tin, which must have been done deliberately,' and 'the cause of the passage from copper to bronze remains completely obscure.'

Excluding, therefore, naturally-occurring minerals containing both copper and tin compounds, one is thrown back on an artificially-made mixture of the two ores, which, however, need not have been intentional in the first place, but which might have happened from the accident of the two ores having been found in close proximity to one another, as they sometimes occur, but only in such a locality, as until bronze was known there was no inducement to transport tin ore from one place to another.³

Being of foreign origin, bronze would naturally have been scarce in Egypt for some time after it first became known and a considerable period would have elapsed before the new alloy was widely used, which is exactly what has been found. It is

¹ G. M. Davies, *Tin Ores*, p. 86.

² C. H. Desch, *Third Report to the Sumerian Committee of Section H*, p. 4. Typed copy kindly supplied by Mr. G. A. Garfitt, Honorary Secretary to the Committee.

³ This subject has been discussed at length by the author elsewhere. (A. Lucas, *Notes on the Early History of Tin and Bronze*, in *Journal of Egyptian Archaeology*, xiv (1928), pp. 106-7.)

always assumed that, though at first imported, bronze was eventually made in Egypt, using imported copper and tin, but for this there is no direct proof. Since, however, other countries in the eastern Mediterranean (for example Greece) made bronze, otherwise there would have been no use for the tin from the west to the commerce in which Herodotus and other classical writers bear testimony, it is not unreasonable to suppose that Egypt was no exception.

Owing to the lack of a large series of chemical analyses of early Egyptian metal objects, there is still some uncertainty about the date when bronze was first used in the country. It is not unusual, too, to find in archaeological reports objects called copper or bronze without any discrimination and sometimes even called copper in one part of a report and bronze in another, as though the terms were synonymous. Disregarding these loose statements, there are a few specimens of undoubted bronze that have been assigned to early periods, which may now be considered. The first in chronological order is a small piece of rod about $1\frac{1}{2}$ inches long with a square cross-section found by Petrie at Medum,^{1, 2} which, if contemporaneous with the material among which it was found, 'must be of the age of Seneferu' ¹ (Fourth Dynasty, about 2900 B.C.). The finder calls it a 'freak' ³ and, although he believes it to be of the age stated, he admits that 'The only doubt can be whether it fell in from above during the work, as I did not find it myself.' ¹ After this comes a ring dated by de Morgan to a little after the end of the Third Dynasty,⁴ but stated by Berthelot to be of uncertain date.⁵ The next in date order is a thin razor stated by Sir Robert Mond to be of the Fourth Dynasty, which on analysis by Professor Desch proved to be bronze containing 8.5 per cent of tin.⁶ Then comes a vase described as of the Sixth Dynasty, but about which no details are given.⁵ From

¹ W. M. Flinders Petrie, *Medum*, p. 36.

² J. H. Gladstone, in *Proc. Soc. Bibl. Arch.*, xiv (1992), pp. 224-5.

³ W. M. Flinders Petrie, *The Arts and Crafts of Ancient Egypt*, p. 104.

⁴ J. de Morgan, *Recherches sur les origines de l'Égypte*, pp. 211-12.

⁵ M. Berthelot, *Étude sur les métaux*, in *Fouilles à Dahchour*, J. de Morgan, 1895, pp. 135, 139.

⁶ *Report of the British Association*, 1933, Abstract in *Nature*, 132 (1933), p. 448.

the Eleventh Dynasty there is a bowl¹ (but as this is merely stated to come from Luxor, without any further details, the dating may be wrong) and also a statuette (found at Meir and said to be the oldest bronze statuette known²). Not later than the Twelfth Dynasty are two bowls found by Garstang at Beni Hasan,³ but as the analyst merely states that tin was present without giving the proportion, they might conceivably be of copper with a small natural admixture of tin, and not bronze. From this same dynasty there are a number of well-authenticated specimens of bronze including tools,⁴ and the Middle Kingdom, therefore, may be considered as the beginning of the Bronze Age in Egypt. From the Eighteenth Dynasty⁴ onwards bronze is well known and during the later periods it was extensively employed for casting small statuettes. The use of bronze, however, did not preclude a considerable use of copper; for instance in the tomb of Tut-ankhamûn there was more copper than bronze. Among the copper objects from this tomb there are a number of miniature implements belonging to the *shawbti* figures, which the author analysed and found that generally they consisted of copper entirely free from tin or containing only a trace, though in a few instances there was a somewhat larger proportion, estimated to be not more than about 2 per cent.⁵ One of the large metal tongues, too, from the shrines that surrounded the sarcophagus, was also tested and proved to be of copper and probably, therefore, all the similar tongues are copper. Dr. A. Scott found the metal band round the base of the outermost shrine to be copper containing 2.5 per cent of tin.⁶

In this connexion it may be mentioned that although occasionally it may be possible to distinguish an ancient copper object from one of bronze by mere inspection, as for instance

¹ G. B. Phillips, *The Composition of some Ancient Egyptian Bronzes*, in *Ancient Egypt*, 1924, p. 89.

² J. de Morgan, *op. cit.*, p. 204.

³ J. Garstang, *The Burial Customs of Ancient Egypt*, pp. 43, 143, 144.

⁴ For references, see p. 426.

⁵ A. Lucas, *Appendix II*, in *The Tomb of Tut-ankh-Amen*, III, Howard Carter, p. 175.

⁶ A. Scott, *Appendix IV*, in *The Tomb of Tut-ankh-Amen*, II, Howard Carter, p. 205.

in the case of thin objects of beaten copper, it is never safe to trust to this for identification and certainty can only come from a chemical analysis.

Bronze Working

Bronze, like copper, was worked by being either hammered or cast. The value of hammering is shown by two experiments made by Desch,¹ in one of which bronze containing 9·31 per cent of tin, which had an initial hardness (Brinell scale) of 136, after hammering gave a hardness of 257, and, in the second of which, bronze containing 10·34 per cent of tin gave figures before and after hammering of 171 and 275 respectively, which, as Desch points out,¹ 'represent a very considerable hardness.'

Bronze was extensively employed in Egypt at a late date for making statuettes, which were cast either solid or hollow, the smaller ones usually being solid and the larger ones hollow, the limbs in human figures, especially the arms, often being cast separately and attached by means of mortise and tenon joints provided for in the casting. The method of casting was that known as the *cire perdue* (lost wax) process, the simplest form of which, as used for solid castings, was as follows: A model in beeswax was made of the object to be cast: this was coated with a suitable material to form the mould, probably clay or a clay mixture, and embedded in sand or earth, which merely acted as a support: the whole was then heated, when the wax melted and either burnt away or ran out through the hole or holes provided to receive the molten metal and the mould became hard and rigid and ready for use: the molten metal was then poured in and allowed to cool, after which the mould was broken away and the object given the necessary finishing touches with a chisel.

The casting of hollow objects was merely a modification of solid casting, manifestly introduced for the sake of economy, since the amount both of wax and of metal was considerably reduced. In this method, a core of quartz sand (probably mixed with a small proportion of organic material to give it sufficient plasticity to enable it to be roughly shaped) was covered with a thin coating of beeswax and the whole fashioned

¹ C. H. Desch, *The Tempering of Copper*, in *Discovery*, VIII (1927).

into the required form, which was then treated as described for solid casting, namely, by covering it with clay or clay mixture to form the mould, embedding it in sand or earth as a support and heating it, when the wax burnt off or escaped and the outer shell became hard and rigid. The molten metal was poured into the space previously occupied by the thin layer of wax between the inner core and the outer mould, and when the metal was cold the jacket was chipped away, the core as a rule being left.

Several specimens of core material from Egyptian bronze statuettes examined by the author all consisted of blackened sand, that is, sand the particles of which were coloured black and not merely mixed with black material. The black was chiefly an iron compound together with occasionally a very small proportion of organic matter. It appears probable that the sand had not originally been black, but that ordinary quartz sand had been mixed with some organic substance in order to impart plasticity and that this in burning away had blackened the sand. Petrie also describes the core material as blackened sand,¹ but Edgar calls it 'a hard, gritty light coloured composition like sand and plaster.'²

The process of casting metal (described in an accompanying inscription as from Syria) into the form of doors for the temple of Amûn at Karnak is shown in the tomb of Rekhmara at Thebes (Eighteenth Dynasty).³ The name of the metal being employed is translated as copper or bronze, but it is much more likely to have been bronze than copper, since the mould is certainly a closed one, for which copper would have been most unsatisfactory, especially for such a large object as a door, and bronze, besides being easier to manipulate, would have given much better results. A similar scene of casting is also depicted in the Eighteenth Dynasty tomb of Menkheperasonb Amenmose.⁴ Of what material the moulds were made it is impossible to determine from the illustrations. Half a closed stone mould

¹ W. M. Flinders Petrie, *The Arts and Crafts of Ancient Egypt*, 1910, p. 101.

² C. C. Edgar, *Greek Bronzes*, in *Cat. Gén. du Musée du Caire*, p. ii.

³ P. E. Newberry, *The Life of Rekhmara*, p. 37; Pl. XVIII.

⁴ N. and N. de G. Davies, *The Tomb of Menkheperasonb Amenmose and Another*, Pl. XI.

for casting something in the nature of ornamental metal heads for poles or feet for furniture is in the Cairo Museum (No. J. 37554). Garland and Bannister state that this 'was clearly used for making shell castings in the manner in which cheap statuettes are produced to-day, by filling the mould and, when a skin had solidified, pouring off the remaining liquid metal.'¹ There are also a number of other stone moulds in the Museum (chiefly for birds and figures), but whether for casting bronze or gold or moulding faience or glass is uncertain.

Brass

Another alloy of copper is brass, which is a copper-zinc mixture, but this was not known until comparatively late in the history of metals, though it antedated by many hundreds of years the discovery of zinc as an individual substance and, therefore, brass, as at first produced, must have been made from copper or copper ore and zinc ore, but not from metallic zinc, and, like bronze, it was probably at first the result of an accident. Ores containing both copper and zinc compounds are sometimes found in nature, for example, in Egypt,² Georgia and Caucasia.

Brass was being shipped down the Red Sea from or through Egypt to Adulis (Massowa) in the first century A.D.³ and brass finger rings and earrings of late date have been found in Nubian graves,^{4, 5}

GOLD AND ELECTRUM

Gold

Gold is found very widely distributed in nature, chiefly in the metallic state, though practically never pure, but generally containing small proportions of silver, sometimes copper and occasionally traces of iron and other metals. It generally occurs in one of two forms, either in irregular masses in veins in quartz rock or in alluvial sands and gravels, these latter having been

¹ H. Garland and C. O. Bannister, *Ancient Egyptian Metallurgy*, p. 55.

² See p. 162.

³ W. H. Schoff, *The Periplus of the Erythraean Sea*, p. 24.

⁴ C. L. Woolley and R. D. Randall-MacIver, *Karanog*, pp. 62, 66.

⁵ C. M. Firth, *Arch. Survey of Nubia, Report for 1910-1911*, pp. 115, 157, 159, 165.

derived from the breaking down of gold-bearing rocks the debris from which has been washed into watercourses, now often dry. In Egypt, gold is found in both these conditions. Owing to its local occurrence, its glittering yellow colour and to the simplicity of the treatment required to separate it for use, gold was one of the oldest metals known in Egypt, though not so old as copper, and it has been found in predynastic graves. Since the extraction of gold from sand and gravel is a simpler process than its extraction from hard rock, primitive races have usually begun gold mining with alluvial gold and the Egyptians were no exception to the rule.

The gold-bearing region of Egypt, which is 'immense,'¹ lies between the Nile valley and the Red Sea, chiefly in that part of the eastern desert stretching south from the Qena-Quseir road to the Sudan frontier, though several old workings have been found considerably north of the latitude of Qena, and many others lie beyond the confines of Egypt in the Sudan almost as far south as Dongola.² The greater part of this territory is in Nubia, the Ethiopia³ of the classical writers, the modern Egyptian portion being Lower Nubia⁴ (from Aswan to Wâdi Halfa) and the Sudan portion Upper Nubia (from Wâdi Halfa to Merowe). No occurrence of gold is known in Sinai, although the geological conditions are favourable and although some of the ancient records might seem to imply that gold was obtained from that region.

Referring to alluvial (placer) gold, Rickard says it⁵ is reported that in a particular district in the eastern desert there are alluvial workings of 'immense extent,' the country having 'the appearance of having been ploughed' and that over an area of 100 square miles the ground has been worked to an average depth

¹ A. Llewellyn, in *Bull. Institution of Mining and Metallurgy*, 352 (1934), p. 23.

² Stanley C. Dunn, *Notes on the Mineral Deposits of the Anglo-Egyptian Sudan*, p. 13.

³ The term Ethiopia was employed very loosely and Abyssinia (the modern inhabitants of which call themselves Ethiopians) and the southern Sudan were sometimes included.

⁴ Nubia did not become a part of Egypt until the Twelfth Dynasty.

⁵ T. A. Rickard, *Copper and Gold Mines of the Ancient Egyptians*, in *Eng. and Mining Journal-Press*, 1925, p. 1008.

of seven feet, and Stewart states¹ that 'the whole of the small valleys in the schists are full of alluvial workings.' Some of these alluvial workings are probably comparatively modern, since gold was exploited in the eastern desert in Arab times. A few years ago Mr. A. H. Hooker, working on behalf of the Egyptian Government, found a very small amount of alluvial gold in the Wâdi Korbiai in the south-eastern desert.

The total number of ancient workings in quartz has been estimated to be at least one hundred.

But whether alluvial (placer) deposits or veins in quartz rock, the ancient Egyptians 'were very thorough prospectors and no workable deposits have been discovered that they overlooked.'²

The gold industry in Egypt was revived some years ago and, although it has now died down again, 83,672 ounces of fine gold of a value of over £350,000 sterling were extracted during the eighteen years from 1902 to 1919 inclusive, but during the following eight years, from 1920 to 1927 inclusive, only 2,867 ounces were extracted.³ Mining was discontinued, not because the gold was exhausted, but on account of the difficulty and cost of the work.

In view of the large amount of gold obtained in modern times and of that still remaining, there cannot be any doubt that the gold from the local mines provided most of the gold used in Egypt anciently, especially during the earlier periods, and that it was even sufficient to permit of export, as is proved by the El Amârna letters. Naturally, however, whenever possible additional gold was levied as tribute or taken as one of the fruits of victory after war, since it was a valuable and desirable metal to possess.

Petrie's statements that 'The Asiatic gold was certainly used in the first dynasty, as it is marked by having a variable amount of silver alloy, about a sixth,'⁴ and that 'Gold from the Ist

¹ P. C. Stewart, quoted by W. F. Hume in *A Prelim. Rept. on the Geol. of the Eastern Desert of Egypt*, p. 54.

² R. H. Greaves and O. H. Little, *The Gold Resources of Egypt*, in *Report of the XV International Geol. Congress, South Africa, 1929*, pp. 123-7.

³ Mines and Quarries Dept., (a) *Report on the Mineral Industry of Egypt, 1922*, pp. 23, 50; (b) *Report for 1928*, pp. 24-5, 44.

⁴ W. M. Flinders Petrie, *The Arts and Crafts of Ancient Egypt, 1910*, p. 83.

to the XIIth dynasty averages 16 per cent of silver, which marks it as Pactolan and not Nubian,'¹ are based on a misconception of the nature of Egyptian gold, which always contains silver and often 16 per cent or more, as will be shown later. Petrie also says that in the Second Dynasty gold 'had antimony in it, which suggests a Transylvanian source, the telluride of gold and antimony.'² This has reference to the sard and gold sceptre of Khasekhemui, which was found by him at Abydos.² Peake and Fleure, elaborating Petrie's statement, say³ '... a fragment of gold, found in the tomb of King Khasekhemui ... has a red antimoniate crust.'⁴ Antimony combines with gold, so far as is known, only in the presence of tellurium, and the only region in the Old World in which gold and tellurium occur mixed is within the ring of the Carpathian mountains. The only rich gold-field within this ring is in Transylvania, where gold has been worked at least from Roman times onwards. ... Meanwhile we note the possibility that gold from Transylvania found its way to Egypt about 3000 B.C.' Peake, writing later, is slightly more definite and says⁵ that 'Gold from Transylvania seems to have reached Egypt before the close of the 2nd dynasty.' Heard repeats this statement in a still stronger form.⁶ Professor Myres, in referring to this gold,⁷ makes two slips, one in calling the ingredient that was found in the gold tellurium instead of antimony and the other in terming it a 'high percentage,' whereas no statement of the proportion in which the antimony occurred has been made. Since the origin of the early Egyptian gold is an important matter, these various statements about a possible Transylvanian source may be examined. Petrie says that the gold in question contained antimony, which is not doubted, as it is understood that the analysis was made by Dr. Gladstone. The proportion in which the antimony occurred, however, is not given, which is to be regretted, since this information

¹ W. M. Flinders Petrie, *Descriptive Sociology, Ancient Egyptians*, p. 57.

² W. M. F. Petrie, *The Royal Tombs of the Earliest Dynasties*, II, p. 27; Pl. IX.

³ H. Peake and H. J. Fleure, *Priests and Kings*, pp. 14-15.

⁴ This object is in the Cairo Museum, and no red coloration can be found on it.

⁵ H. Peake, Article 'Gold,' in *Ency. Brit.*, 14th ed. (1929), Vol. 2, p. 252.

⁶ G. Heard, *The Emergence of Man*, p. 161.

⁷ J. L. Myres, *The Discovery and Early Use of Metals*, in *Early Man*, p. 143.

would have been valuable, but presumably it was present only in small amount, possibly as a trace. An ancient method of refining gold (how ancient is not known) was by means of sulphide of antimony, which was very liable to leave a little antimony in the gold, though, as this method was certainly not practised as early as the Second Dynasty, this does not explain the antimony in the particular gold under consideration, but it does show that the presence of antimony in gold is no proof that the gold was obtained from Transylvania.

The statement that, so far as is known, antimony only combines with gold in the presence of tellurium, is also misleading, since antimony alloys readily with gold in practically all proportions without the help of tellurium, and no evidence can be found that antimony ever forms a red antimoniate of gold.

That the gold in question was obtained from Transylvania and, therefore, that gold, especially in the form of such an ore as gold telluride, was being worked there and traded to Egypt (a country where gold occurred in abundance and was well known at the time) even in small amount, as early as the Second Dynasty (about 3000 B.C.) is so improbable that it may be entirely disregarded.

There are written records of gold being brought to Egypt from the south in the Twelfth Dynasty, but no record can be found of gold having been brought to Egypt from the North before the Nineteenth Dynasty. The places mentioned as sources of gold are as follows :

South : Twelfth Dynasty¹ (Koptos ; Nubia) ; Eighteenth Dynasty² (Highlands ; Karoy ; Koptos ; Kush ; Punt ; South Countries) ; Nineteenth Dynasty³ (Akita ; God's Land ; Karoy ; Punt) ; Twentieth Dynasty⁴ (Edfu ; Emu ; Koptos ; Kush ; Malachite Country ; Negro Lands ; Ombos).

North : Nineteenth Dynasty (Libya)⁵ ; Twentieth Dynasty (Asia)⁶ ; Twenty-second Dynasty (Khenthennofer).⁷

The oldest known map in the world, which is now in the Turin Museum, is one on papyrus showing a gold-bearing

¹ J. H. Breasted, *op. cit.*, I, 520, 521.

² II, 263, 373, 502, 514, 522, 526, 652, 774, 889.

³ III, 37, 116, 274, 285, 286.

⁴ IV, 30, 33, 34, 228, 409.

⁵ III, 584.

⁶ IV, 26.

⁷ IV, 770.

region in the eastern desert of Egypt. This dates from the reign of Seti I (Nineteenth Dynasty ; 1313 B.C. to 1292 B.C.).

Gold Mining

The ancient method of treating gold ores to obtain the metal was very simple. In the case of alluvial gold, the sand or gravel was merely washed with running water, which carried away the lighter material, leaving the heavier gold particles behind, which were collected and fused into small ingots: occasionally doubtless small nuggets of gold were also found.

The Egyptian method of extracting gold from the veins in quartz rock is described by Agatharchides, a Greek writer of the second century B.C., who visited the mines and wrote a detailed account of what he had seen. Although the original work has been lost, the description of the gold mines has fortunately been preserved by Diodorus, who quotes it in full.¹ The hardest of the rock was first cracked and broken by means of fire and then attacked by hand tools, which alone were used for the softer rock. The detached rock was then carried outside the mine, where it was crushed in large stone mortars to the size of peas and afterwards ground to fine powder in hand mills, this powder being then washed with water on a sloping surface in order to separate the metal, which was finally fused into small ingots.

The results of the analyses of eighteen different specimens of gold from ancient Egyptian objects will be found in the Appendix,² from which it will be seen that the percentage of gold varies from 72·1 (17 carats) to 99·8 (23·5 carats). Mrs. Ransome Williams gives the fineness of the better quality of ancient Egyptian gold jewellery as ranging from 70·8 per cent (17 carats) to 91·7 per cent (22 carats), but mentions specimens as low as 13, 12 and 9 carats respectively.³

Thomas gives the results of the assay of five samples of gold from modern Egyptian mines as ranging from 84·0 per cent of gold (20 carats) to 90·3 per cent (21·5 carats),⁴ assuming

¹ III, 1.

² See p. 427.

³ C. R. Williams, *Gold and Silver Jewelry and Related Objects*, p. 25.

⁴ E. S. Thomas, *Notes on the Mining Industry of Egypt*, in *Cairo Scientific Journal*, III (1909), p. 112.

silver to have been the only impurity. A very considerable number of other results taken from the actual working on a large scale of the six principal modern Egyptian mines varied from 77·0 per cent (18·5 carats) to 86·0 per cent (20·5 carats),¹ again assuming silver to be the only impurity.

Gold in the form of large rings, believed to have been alluvial gold from Abyssinia, received at the Egyptian Government Assay Office was about 91·7 per cent (22 carats) pure, and gold bars received for assay from a mine in the eastern desert were about 83·3 per cent (20 carats).

The principal impurity, and sometimes the only one of importance, in Egyptian gold is silver, with occasionally a little copper and a trace of iron.

Gold Refining

Judging from the results of the analyses of ancient Egyptian gold objects,² gold was not purified or refined in any way until about the Persian period (525 to 332 B.C.), though the Egyptian records mention fine gold; gold of two times and gold of three times in the Twentieth Dynasty (1200 to 1090 B.C.)³ and fine gold in the Twenty-first Dynasty (1090 to 945 B.C.),⁴ which suggest refining. In the second century B.C. Agatharchides describes a method of refining gold practised in Egypt by heating it with lead, salt, tin and barley bran,⁵ no provision however being made for the recovery of the silver, which must have been lost. Towards the close of the Eighteenth Dynasty and onwards gold was sometimes debased by the addition of copper, and Petrie states that many of the finger rings of the late Eighteenth Dynasty 'almost verge into copper.'⁶ A ring of this nature, of late but uncertain date, analysed by the author consisted of approximately 75 per cent of copper and 25 per cent of gold.

¹ Kindly communicated by Mr. R. H. Greaves, formerly Controller, Mines and Quarries Department, Egypt.

² See p. 427.

³ J. H. Breasted, *op. cit.*, IV, 228, 231, 245, 285, 327, 331, 343, 385, 386, 389, 408, 491, 498.

⁴ IV, 610.

⁵ Quoted by Diodorus, III, 1.

⁶ W. M. Flinders Petrie, *The Arts and Crafts of Ancient Egypt*, p. 94.

Gold Working

That the Egyptian goldsmiths were craftsmen of a very high degree of skill is exemplified by certain of their products that have been preserved, for instance the gold work in the tomb of Hetepheres (Fourth Dynasty)¹, behind which there must have been a long history of gold working; that found at Dahshûr and el-Lahûn (Twelfth Dynasty)^{2, 3, 4} and that from the tomb of Tut-ankhamûn (Eighteenth Dynasty)^{5, 6}. Some of their operations are depicted on the walls of certain tombs, for example in the tomb of Ti at Saqqâra (Fifth Dynasty)⁷; in the tomb of Mera at Saqqâra (Sixth Dynasty); in a tomb at Beni Hasan (Twelfth Dynasty)⁸ and in the tomb of Rekhmara at Thebes (Eighteenth Dynasty).⁹

Even as early as the Fourth Dynasty the ancient goldsmiths were manifestly able to manipulate comparatively large amounts of gold at one time, as shown by the gold work on the canopy of Hetepheres and by the time of the Eighteenth Dynasty they were making solid gold coffins like that of Tut-ankhamûn, which is 6 feet $1\frac{3}{4}$ inch long, weighs approximately 296 pounds Troy (110.4 kilograms) and is engraved inside as well as outside.

Gold was shaped both by hammering and casting; it was engraved and embossed; it was made into thin sheets for decorating furniture, wooden coffins and other objects, for plating copper and for cutting into thin strips to make wire; it was beaten into still thinner leaf for gilding; it was coloured and it was soldered, in fact there are few of the modern practices of working gold that were not known and employed in ancient Egypt. The details of the methods used for making jewellery

¹ G. A. Reisner, in *Bull. of the Museum of Fine Arts, Boston*, xxv (1927), special supplement; xxvi (1928); xxx (1932).

² J. de Morgan, *Fouilles à Dahchour*, mars-juin, 1894 and 1894-5.

³ G. Brunton, *Labun I, The Treasure*.

⁴ A. M. Lythgoe, *The Treasure of Labun*, in *Bull. Met. Mus. of Art, New York*, II, 1919.

⁵ Howard Carter and A. C. Mace, *The Tomb of Tut-ankh-Amen*, I.

⁶ Howard Carter, *The Tomb of Tut-ankh-Amen*, II, III.

⁷ G. Steindorff, *Das Grab des Ti*, Pl. 134.

⁸ P. E. Newberry, *Beni Hasan*, I, Pl. XI.

⁹ P. E. Newberry, *The Life of Rekhmara*, Pl. XVIII.

have been studied and described by Mrs. R. Williams¹ and by Vernier.²

Specimens of sheet gold (foil) measured by the author have varied from 0.17 mm. to 0.54 mm. in thickness and the leaf has varied from 0.01 mm. to 0.09 mm. Petrie states that it 'was often about a 5,000th of an inch thick,'³ or 0.127 mm. The ancient gold leaf, however, was not nearly as thin as the modern article, which ranges from 0.00008 to 0.0002 mm. in thickness.⁴

When gold foil (i.e. thick sheet gold), which was generally embossed or engraved, was employed for decorating wooden objects, it was put directly on to the wood and fastened in place with small gold rivets, but when thinner sheet gold was used, the wood was first covered with a layer of special plaster (gesso) to which the gold was attached by means of an adhesive, probably glue. For gilding with the still thinner gold leaf, a similar layer of plaster was used, but the nature of the adhesive is not certain, though Professor Laurie believes that in one case he has found evidence of the use of white of egg for this purpose.⁵

Gold Plating

Both copper and silver were plated with gold. The plating of copper was done in two different ways: one in which thin sheet gold was hammered on to the copper, and the other where thin gold leaf was fastened on with an adhesive, which, in the specimens that have been tested, is soluble in water and is, therefore, probably gum or glue. Examples of the first-named technique are a small button seal of about the Sixth Dynasty kindly shown to me by Mr. Guy Brunton; one ibis amulet,⁶ and probably two,⁶ and several objects, probably bracelets,⁷ all found by Brunton and dating from the period Seventh to Eighth

¹ C. R. Williams, *Gold and Silver Jewelry and Related Objects*.

² E. Vernier, (a) *Bijoux et orfèvreries*, in *Cat. Gén. du Musée du Caire*; (b) *La bijouterie et la joaillerie égyptiennes*, in *Bull. de l'Inst. Franc de l'Archéol orient du Caire*, II, 1907.

³ W. M. Flinders Petrie, *The Arts and Crafts of Ancient Egypt*, p. 96.

⁴ Sir Ed. Thorpe, *A Dict. of Applied Chemistry*, 1912, III, p. 781.

⁵ A. P. Laurie, *Methods of Testing Minute Quantities of Material from Pictures and Works of Art*, in *The Analyst*, LVIII (1933), p. 468.

⁶ G. Brunton, *Qau and Badari II*, p. 12.

⁷ G. Brunton, *op. cit.*, I, p. 66.

Dynasty. Examples of the second-named technique are the large 'marguerites,' which are probably of copper, that were sewn to the linen pall from the tomb of Tut-ankhamûn,^{1, 2} and probably also the identical-looking 'marguerites' from the so-called 'Tomb of Queen Tîyi.'³

As instances of the gold plating of silver may be mentioned the Twenty-second Dynasty pectoral and the dagger blade both cleaned by the author⁴ and described by Vernier.⁵

Gold Colouring

One very noticeable feature of ancient gold is its varied colour, which comprises bright yellow, dull yellow, grey and various shades of red, including reddish-brown, light-brick colour, blood colour, dull purple (purple-plum colour) and a very remarkable rose-pink, all, except the last-named, being fortuitous. The bright yellow gold is fairly pure; the dull and tarnished yellow contains small proportions of other metals, such as silver and copper, which where exposed have undergone chemical change. The grey gold contains a large proportion of silver, which on the surface has become converted into chloride of silver, that has darkened in the manner usual with this compound. The reddish-brown colour gives the tests for iron and copper and is evidently due to these metals having become oxidized. In some instances a red or purple colour has proved to be a staining of the gold by organic matter. The rose-pink colour occurs on a number of objects in the Cairo Museum, for example on the diadem from the tomb of Queen Tewosret⁶ (Nineteenth Dynasty) and on the earrings of Ramesses XI (Twentieth Dynasty), but more particularly on a number of the

¹ Howard Carter, *The Tomb of Tut-ankh-Amen*, II, p. 33; Pl. IV.

² A. Lucas, *Appendix II*, p. 172, in *The Tomb of Tut-ankh-Amen*, II, Howard Carter.

³ Theodore M. Davis, *The Tomb of Queen Tîyi*, p. 40.

⁴ A. Lucas, in *Annales du Service*, XXIV (1924), pp. 15-16.

⁵ E. Vernier, *Bijoux et orfèvreries*, pp. 240-1, 378-9; Pls. LXIII-IV; LXXVII.

⁶ Theodore M. Davis, *The Tomb of Siptah: The Monkey Tomb and the Gold Tomb*. Plate without number entitled 'Gold Bracelets and Ornaments of Queen Taousrêt' on which a rosette (possibly from the diadem) is coloured rose-pink.

gold objects from the tomb of Tut-ankhamûn, which latter was reported upon several years ago by the author as follows :¹ 'The rose colour can be proved by chemical analysis not to be due to any colloidal modification of the gold, nor to any sort of organic lacquer or varnish, and the gold can be made red-hot without the colour being removed or diminished, but in some instances rather enhanced. The coloured film, however, is so extremely thin, being probably less than one hundred-thousandth of an inch in thickness, that without more material than it is desirable to use, chemical analysis becomes very difficult. A trace of iron is the only metal found so far, and since it is well known that native gold is sometimes reddened by being coated with a translucent film of oxide of iron, it is suggested that the colour in question is probably due to oxide of iron, but in what manner it was produced is not known, as it occurs on both sides of most objects on which it is present. This suggests that the object may have been dipped in a solution of an iron salt and then heated. That this colour is intentional is shown by its regular and systematic distribution on certain objects or on certain parts of objects.' The predictions that the rose-pink colour was due to iron and that it had been produced by heating have been proved to be correct by Professor R. W. Wood of The Johns Hopkins University, Baltimore,² who has reproduced the colour so exactly that put side by side with the original it cannot be distinguished from it. The colour was made by fusing pure gold with a slight trace of iron.

Electrum

Electrum is an alloy of gold and silver, which may be either natural or artificial, but which originally was natural, that employed in ancient Egypt being probably always natural. These alloys may contain almost any proportion of the two constituents, and when the amount of gold is high the appearance is that of ordinary gold, and when the content of silver

¹ A. Lucas, *Appendix II*, p. 174, in *The Tomb of Tut-ankh-Amen*, II, Howard Carter.

² R. W. Wood, *The Purple Gold of Tut-ankhamûn*, in *Journal of Egyptian Archaeology*, xx (1934), pp. 62-5. The specimen of gold coloured by Professor Wood is now in the Cairo Museum.

is high the colour is silver-white and the metal would pass as silver. Such extremes, however, are not called electrum, the term being limited to an alloy of a pale yellow colour, and it was this that the Greeks termed *electron* and the Romans *electrum*, usually stated to have been so-called from its resemblance in colour to amber, the name for which, as used by Homer and Hesiod, was *electron*, though, since the alloy was probably the earlier known, the reverse seems likely to have been the case.

In the ancient records electrum is stated to have been brought to Egypt from Punt¹; Emu²; the Highlands³; the South Countries⁴; from a mine east of Redesîa⁵ and from the mountains,⁶ all places south of Egypt, and there is no reference to its having been obtained from the North, and no evidence whatever that it ever reached Egypt from Pactolus, as stated by Petrie.⁷ The division between gold and electrum is entirely arbitrary, and when the alloy contains less than 20 per cent of silver it is here called gold and when it contains 20 per cent or more of silver and is of a light yellow colour it is here called electrum, which accords with Pliny's definition.⁸

The various specimens of ancient Egyptian electrum of which analyses are recorded⁹ show a silver content varying from 20.3 to 29.0 per cent, and some electrum finger rings in the Cairo Museum, that it is not possible to analyse, have approximately the same shade of light yellow as a gold-silver alloy of 15 carats, which corresponds to 37.5 per cent of silver.

From the results of the assay of modern Egyptian gold already quoted, there cannot be any doubt that electrum is found in the country and it seems highly probable that the supply sufficed to meet the local needs. The reason that electrum is not usually recognized as occurring in Egypt is that the modern gold prospector and gold miner consider it to be merely a poor quality of gold, since it has no value at the present day except as a source of gold and silver.

Electrum is harder than gold and, therefore, is the better fitted of the two for the wear and tear incidental to its use

¹ J. H. Breasted, *op. cit.*, I, 161; II, 272.

² II, 298, 387.

³ II, 374, 377.

⁴ II, 654.

⁵ III, 403.

⁶ IV, 28.

⁷ W. M. Flinders Petrie, *Social Life in Ancient Egypt*, p. 164.

⁸ xxxiii, 23.

⁹ See p. 428.

for jewellery, and this fact may have influenced its use in ancient Egypt.

Electrum was employed for the same purposes and in the same manner as gold, namely, for jewellery and for coating wooden objects such as furniture and coffins and it can be traced back to early dynastic times.

IRON

Though compounds of iron are exceedingly abundant in nature, metallic iron is rare and usually occurs in comparatively small amount. This native iron is of two different origins and two different kinds, (a) terrestrial, occurring generally as minute grains in certain volcanic rocks, but also, though very exceptionally, in large masses, probably only one such occurrence (in Greenland) being known; and (b) celestial, this being dust or fragments from meteorites consisting of, or containing, iron. Meteoric iron possesses one very useful distinguishing characteristic, namely, that it almost invariably contains the metal nickel, the proportion varying from about 5 to about 26 per cent,¹ but usually being about 7 or 8 per cent, whereas terrestrial iron and iron ores rarely contain nickel and, when present, it is only in very small amount.

Iron minerals are very plentiful in Egypt and at a very early date (predynastic times) an ore of iron (haematite) was fashioned into beads, amulets and small ornaments² and certain compounds of iron, namely, red and yellow ochres, were used as pigments.³ The ores are found chiefly in the eastern desert and in Sinai^{4, 5} and the ochres principally near Aswan and in the oases of the western desert.⁶

There are few subjects that are more disputed than that of the date when iron first came into general use in Egypt. Just as some wonderful and mysterious hardened copper or bronze

¹ T. A. Rickard, *Man and Metals*, II, p. 846.

² See p. 344.

³ See pp. 289, 291.

⁴ W. F. Hume, *The Distribution of Iron Ores in Egypt*.

⁵ W. F. Hume, *Explan. Notes for the Geol. Map of Egypt*, pp. 38-9.

⁶ L. Nassim, *Minerals of Economic Interest in the Deserts of Egypt*, in *Report of Congrès Intern. de Géog., Le Caire, 1925*, III (1926), pp. 164-5.

(the composition and secret of the preparation of which have been lost) has been postulated to account for the early Egyptian work in hard stone, so it is often claimed that not only iron but steel must have been known and employed for this purpose.^{1, 2, 3} The fact that a few specimens of iron of early date have been found has been used to support this argument, and it is stated that it is only on account of the easily oxidizable nature of iron that tools and other objects of this metal have not been more frequently discovered. Iron, however, although it does oxidize readily in damp soil, particularly if salt is present, is quite stable under the ordinary conditions that prevail in rock-cut and other tombs in Egypt into which water has not penetrated, and the fact that some few specimens of iron have survived is proof that had there been other examples under similar conditions these too would have lasted. It should not be forgotten also that iron when it oxidizes does not disappear, but is converted into a compound that is not only permanent but which, on account of its reddish colour and of its greater volume than that of the original metal, should not escape observation.

Those who believe that iron tools must have been employed for the early Egyptian work in hard stone attach considerable importance to a piece of iron found at the great pyramid of Giza,⁴ and see in this a proof that iron tools were used in its construction, in support of which the reference in Herodotus to iron tools in connexion with the pyramid is quoted.⁵ By far the greater part of the stone of the pyramid, however, is not hard and there would be no great difficulty in working it without iron tools, and the specimen of iron found is not a tool and does not appear to be part of a tool of any sort, and it is significant that the earliest iron objects are chiefly weapons and personal ornaments and not tools. Herodotus was not discussing the tools employed in the construction of the pyramid, but the cost of the pyramid, and incidentally includes that of

¹ Sir R. Hadfield, *Sinhalese Iron and Steel of Ancient Origin*, in *Journal of the Iron and Steel Institute*, 1912, pp. 134-86, 149, 150, 169, 182.

² J. de Morgan, *Recherches sur les origines de l'Égypte*, pp. 213, 214.

³ H. Garland and C. O. Bannister, *Ancient Egyptian Metallurgy*, pp. 85-112.

⁴ See p. 195.

⁵ II, 125.

the tools, which he assumes to have been of iron because iron tools for stone working were familiar to him. Thus he says ' . . . how much must needs have been expended on the iron with which they worked . . . '

The specimens of early iron found in Egypt may now be described. The earliest are two lots of small tubular beads (one lot of seven and one lot of two) of predynastic date found by Wainwright at El Gerzeh.¹ When found, the beads were entirely in the condition of oxide, but Professor Gowland, who analysed them, stated that originally they had been metallic iron and had been made by bending into tubular shape a thin strip of metal. These beads have since been analysed by Professor Desch and found to contain 7.5 per cent of nickel,² thus proving that the iron of which they were made was of meteoric origin. The next specimen in date order is that already referred to from the pyramid of Cheops which was found in the stonework on the outside.³ Although the statements of the finder (Mr. J. R. Hill) and others, who examined the spot at the time, are very definite and precise and not lightly to be disregarded, it seems more probable, since the iron has been proved not to be meteoric,⁴ that it is of recent date and that it had been lost down a crack in the stone facing of the pyramid when this was being removed for use as building material in modern times.⁵ The next specimens are several pieces of a pickaxe found by Maspero at Abusir stated to be possibly of Sixth Dynasty date,⁶ the finder himself not being certain about the matter. The correctness of the dating, therefore, may reasonably be questioned. Then comes a mass of iron rust found by Petrie with copper adzes of Sixth Dynasty

¹ G. A. Wainwright, in *The Labyrinth, Gerzeh and Mazghuneh*, W. M. Flinders Petrie and others, pp. 15-16.

² C. H. Desch, *Report on the Metallurgical Examination of Specimens for the Sumerian Committee of the Brit. Assn.*, in *Rept. of the Brit. Assn.*, 1928.

³ H. Vyse, *The Pyramids of Gizeh*, I, pp. 275-6.

⁴ T. A. Rickard, *Meteoric Iron in Antiquity*, in *Man*, xxvii (1927), 56.

⁵ The author at one time thought that this iron must be contemporaneous with the pyramid, but on reconsidering the evidence in the light of the recently ascertained fact that the iron is not meteoric, he is now of opinion that the balance of evidence is against its being ancient.

⁶ G. Maspero, *Guide au Musée du Boulaq*, 1883, p. 296.

type,¹ of which the finder says 'this is absolutely certain and not open to any doubts.'² When tested chemically, this was found to contain only a trace of nickel and hence it is probably not meteoric. There is no proof that it was a tool or implement of any kind and what it was and how it came to be placed in the foundations of a temple at Abydos will probably always remain a mystery; but it may have been a piece of iron produced accidentally that could not be used because the art of shaping it while red-hot had not then been discovered.

After that comes an iron spear-head from Nubia, which is attributed to the Twelfth Dynasty,³ but that iron should be known and employed in an out-of-the-way place in Nubia in the form of a large weapon for common use more than four hundred years before the time when the king of Egypt (Tut-ankhamûn) possessed only one iron weapon (a dagger) and that much smaller and more than 1,000 years before iron became common in Egypt, is so extraordinary that more evidence than that adduced is necessary before the date assigned to this object can be accepted, especially as it is practically identical with spear-heads used until not many years ago in the same locality. Then comes part of a chisel and part of a hoe stated to be of the Seventeenth Dynasty,⁴ but of which nothing precise is known. From the tomb of Tut-ankhamûn (late Eighteenth Dynasty) there are several iron objects,⁵ namely, a dagger, a miniature head-rest, an amuletic eye set in a gold bracelet and sixteen implements having full-sized handles of some coniferous wood, but with blades so small and thin that they could not even have been used by the boy king to play with, the total weight of all the blades being only about four grams, and Wainwright has shown that these were probably magical implements for the ritual ceremony of 'Opening the Mouth' of the mummy of the dead Pharaoh.⁶ Whether these are of meteoric iron, as theoretically they should be, is not known, since an

¹ W. M. Flinders Petrie, *Abydos*, II, pp. 32-3.

² W. M. Flinders Petrie, *The Arts and Crafts of Ancient Egypt*, p. 104.

³ D. Randall-MacIver and C. L. Woolley, *Buhen*, pp. 193, 211; Pl. 88.

⁴ G. Maspero, *op. cit.*, p. 296.

⁵ Howard Carter, *The Tomb of Tut-ankh-Amen*, II, pp. 109, 122, 135; Pls. LXXVII, LXXXII, LXXXVII; III, pp. 89-90; Pl. XXVII.

⁶ G. A. Wainwright, *Iron in Egypt*, in *Journ. Egyptian Archaeology*, XVIII, p. 7.

analysis has not yet been made. The head-rest, which is a typical object, and therefore probably made in the country, has been badly welded and shows several imperfections due either to lack of experience in working iron or to the absence of a sufficiently high temperature.

From the time of Tut-ankhamûn onwards, there is a gradual increase in the number of iron objects found, until the Twenty-fifth Dynasty (712 to 663 B.C.), of which date there is a group of iron tools,¹ after which iron becomes much more common and at Naukratis and Defenneh in about the Twenty-sixth Dynasty (663 to 525 B.C.) it was as common as bronze or even commoner and was being smelted in the country.² In 255-254 B.C. iron tools were being supplied to quarrymen.³

It is evident, therefore, that on at least one occasion and at a very early date a very small quantity of meteoric iron was found in Egypt and made into beads, but there was no knowledge of what iron was or how to extract it from its ores and probably not even the knowledge that this particular piece of material had fallen from the sky, though at a later date other finds of meteoric iron, if there were any, may have been recognized as such and may have been used for making small objects for ritual purposes, as suggested by Wainwright.⁴ With five alleged exceptions (four of which are almost certainly of much later date than that assigned to them) this condition of things continued until the end of the Eighteenth Dynasty, when an iron dagger and sufficient iron to make sixteen tiny blades, a miniature head-rest and a small amulet came into the possession of Tut-ankhamûn, almost certainly having been presented to him by one of the kings of western Asia, the home of iron-working. Iron, however, must have been quite a new discovery and unknown in Syria and Palestine during the early part of the Eighteenth Dynasty, since among the tribute levied by Egypt on the peoples she conquered there is no mention of iron.⁵

The earliest date for which at present there is evidence of

¹ W. M. Flinders Petrie, *Six Temples at Thebes*, pp. 18-19.

² W. M. Flinders Petrie, *Naukratis*, I, p. 39; *Nebesheh and Defenneh*, p. 77.

³ J. P. Mahaffy, *The Flinders Petrie Papyri*, II, p. 7.

⁴ G. A. Wainwright, in *Journ. Egyptian Archaeology*, XVIII (1932), pp. 3-15.

⁵ H. R. Hall, *Note on the Early Use of Iron*, in *Man*, III (1903), 86.

iron ores having been worked for metal in Egypt is that of the discovery by Petrie of smelting at Naucratis (sixth century B.C.)¹ in the north-west of the Delta, but where the ore came from is not known. Iron ores, however, have been worked anciently in the eastern desert^{2, 3, 4} and near Aswan,^{4, 5} in the former locality possibly by the Romans.

The principal reason that iron became known to man so much later than copper, although iron ores are far more abundant than copper ores and almost as easy to smelt, is probably due to the fact that copper can be shaped by cold-hammering, whereas iron must be hammered hot, and doubtless impure metallic iron had been produced accidentally many times and rejected as useless long before someone tried hammering it while still hot and found that under such conditions it was almost as malleable as copper.

Iron can be reduced from its ores at a temperature not exceeding 500° C.,⁶ but it does not become liquid enough to be poured for casting until about 1,500° C., which is much too high a temperature to have been obtained anciently, and furnace construction only advanced sufficiently for this to be done in the fourteenth century, only a few hundred years ago. Casting, therefore, was impossible and in this respect iron was inferior to copper and bronze and, since iron was also more difficult to work, because less malleable and, since it was little, if any, harder than copper and bronze, the new metal was at first not so satisfactory as the old ones.

The early wrought iron, on account of the way it was made, would contain little or no carbon (less than 0.2 per cent) and such iron is not hardened but softened if heated and suddenly cooled; but with an increase in the proportion of carbon present, this property of being hardened is acquired, and it is this higher proportion of carbon (from 0.2 per cent to not more than 2.0

¹ W. M. Flinders Petrie, *Naukratis*, p. 39.

² T. Barron and W. F. Hume, *Topog. and Geol. of the Eastern Desert of Egypt, Central Portion*, pp. 44, 51, 86, 221, 222, 225, 239, 257.

³ W. F. Hume, *The Distribution of Iron Ores in Egypt*, p. 8.

⁴ J. de Morgan, *Cat. des monuments et inscriptions de l'Egypte antique*, I, pp. 139-41.

⁵ P. Bovier-Lapierre, *Note sur le traitement métallurgique de fer aux environs d'Assouan*, in *Annales du Service*, XVII (1917), pp. 272-3.

⁶ H. Louis, *Iron Manufacture and Heat Generation*, in *Nature*, 123 (1929), p. 762.

per cent), with the resultant virtue it imparts, that constitutes the difference between wrought iron and steel, steel being iron containing small proportions of added carbon (the carbon content of the ordinary modern product ranging from about 0.7 to 1.7 per cent) that imparts to it the property mentioned, and iron only became a thoroughly serviceable metal for weapons and tools after the discovery of the method (for a long time purely empirical and without any understanding of the underlying principle) of adding a little extra carbon (carburising, as it is termed), so that when heated and suddenly cooled (quenched) it became hardened.¹ This result may be brought about by allowing the iron to remain in contact with carbon at a high temperature for some time, when a certain small proportion of the carbon is absorbed by the iron, the amount depending upon the length of time the two are kept in contact, being greatest at the surface and gradually lessening towards the centre. At one time a process (called the cementation process) employed for making steel, which is still used to some extent, was to pack the iron in charcoal and heat it strongly for several days. Such a considered method, however, is a comparatively late invention, but a similar result can be brought about by the frequent heating and reheating of iron in a charcoal fire, and this must have been the method practised anciently, probably an outcome of the hammering and reheating that were necessary to free the lumps of iron as at first produced from adherent slag and other impurities and to consolidate the metal, which would contain air-holes.

A number of ancient Egyptian iron weapons and tools have recently been examined by Sir Harold Carpenter² from the point of view of their carbon content and the treatment to which they have been subjected and he has proved that some of the specimens examined, ranging in date from about 1200 B.C. to about 800 B.C.³ have been carburised with subsequent heat treatment and quenching.

¹ Steel may be directly produced by smelting certain kinds of iron ore (H. Louis, *op. cit.*, p. 762).

² Sir H. Carpenter, *The Metallography of some Ancient Egyptian Implements*, in *Nature*, 125 (1930), pp. 859-62.

³ With respect to this dating, see note, p. 406.

Since the production of iron from its ores was not an Egyptian discovery, it is most unlikely that the subsequent metallurgical treatment should have been Egyptian, and it seems highly probable, therefore, that blacksmiths from Asia were introduced into the country in order to teach the Egyptians how to smelt and treat the new metal.

LEAD

Although never very extensively employed in ancient Egypt, lead was among the earliest metals known, since it dates from predynastic times.¹ The reason for this early knowledge of lead was doubtless owing to the facts, first, that lead ores occur in Egypt, one of them (galena) being very metallic-looking and, therefore, likely to attract attention, and second, that the metal is very easily obtained from the ore.

The principal locality in Egypt where lead ores are found is at Gebel Rosas,^{2, 3} which is situated about 70 miles south of Quseir and a few miles inland from the Red Sea, but there are deposits in other places, namely, at Ranga on the Red Sea coast^{2, 3}; in the Safaga district near the Red Sea,^{2, 3} where about two miles south of Safaga Bay there is an ancient working covering the whole side of a limestone hill⁴; associated with the Um Samiuki copper ore⁵ and near Aswan.^{2, 3} During the four years from 1912 to 1915 inclusive when the Gebel Rosas mine was being worked it produced more than 18,000 tons of ore, in the form of mixed carbonate and sulphide of lead associated with carbonate of zinc.² The ore contains the equivalent of from 25 to 55 per cent of metallic lead, a very small proportion of silver and also a trace of gold.⁶ Hall states

¹ W. M. Flinders Petrie, *Prehistoric Egypt*, p. 27.

² Mines and Quarries Department, *Report on the Mineral Industry of Egypt*, 1922, p. 24.

³ W. F. Hume, *Explan. Notes to the Geol. Map of Egypt*, pp. 38-9.

⁴ C. J. Alford, *Gold Mining in Egypt*, in *Journ. Inst. Mining and Metallurgy*, 1901, p. 13.

⁵ See p. 162.

⁶ Kindly communicated by Mr. R. H. Greaves, formerly Controller, Mines and Quarries Dept.

that 'analyses show up to 58 per cent lead and 37 per cent zinc.'¹

The principal ore of lead is the sulphide (galena), which was used in Egypt as an eye-paint from as early as predynastic times to as late as the Coptic period.²

The production of metallic lead from its ores is one of the simplest of all metallurgical operations and consists essentially in merely roasting the ore, which is now done in special furnaces, though doubtless in ancient times by simply heaping the ore on top of the fuel on the ground or in a shallow pit, the fused metal, which melts at 327° C. (or less than one-third the temperature required to melt gold) running out at the bottom of the heap.

Lead was used for many purposes, including small human and animal figures^{3, 4}; sinkers for fishing nets⁴; rings⁴; ornaments⁴; model dishes and trays⁴; plugs⁵; for adding to bronze (more than 20 per cent having sometimes been used, which must have lowered the melting point of the bronze considerably, and thus made casting easier); occasionally for vessels⁶ and sometimes for filling bronze weights and as a core for bronze statuettes. Sulphide of lead (galena), as already stated,⁷ was extensively employed as an eye-paint; a compound of lead and antimony was used for producing a yellow colour in glass⁸ and three examples are known of the use of oxides of lead as pigments, one being red oxide (red lead) in a mural painting of Graeco-Roman date,⁹ the second being red lead on a scribe's palette (undated, but most probably of a late period)¹⁰ and the third being yellow oxide (massicot) on a scribe's or artist's palette dating from about 400 B.C.¹¹

There can be little doubt that most, if not all, the lead and

¹ T. C. F. Hall, *Lead Ores*, p. 63.

² See p. 80.

³ W. M. Flinders Petrie, *Prehistoric Egypt*, p. 27.

⁴ W. M. Flinders Petrie, *Objects of Daily Use*, p. 49.

⁵ L. Borchardt, *Das Grabdenkmal des Königs Sa-Hu-Re*, I, pp. 76-7; Fig. 102.

⁶ E. A. Gardner, *Naukratis*, II, p. 29.

⁷ See p. 79.

⁸ See p. 125.

⁹ See p. 290.

¹⁰ J. Barthoux, *Les fards, pommades et couleurs dans l'antiquité*, in *Congrès internat. de Géog. Le Caire, avril, 1925*, IV (1926), pp. 257-8.

¹¹ A. P. Laurie, *Ancient Pigments and their Identification in Works of Art*, in *Archæologia*, LXIV (1913), pp. 318-19.

galena used in Egypt until about the Eighteenth Dynasty was of local origin and there is no evidence that it was 'probably brought from Syria' ¹ until after the Egyptian conquests in Asia, when according to the translation of the ancient records, it was imported from Zahi ²; Retenu ³ and Isy, ⁴ the latter not being Cyprus, as often stated, where lead ores do not occur, but, as shown by Wainwright, ⁵ a country on the northern coast of Syria.

PLATINUM

Platinum is only found in the metallic state and never pure, but always associated with other metals, principally the closely related ones, iridium, palladium, osmium, rhodium and ruthenium, but also frequently with gold.

Only one occurrence of the intentional use of platinum in ancient Egypt is known, namely a narrow strip inlaid in a metal case of late date, which Berthelot examined and found to be 'd'un alliage complexe renfermant plusieurs des métaux de la mine de platine sans prejudice d'un peu d'or.' ⁶ Several gold objects of Twelfth Dynasty date in the Cairo Museum show numerous silver-white specks that the author has tested, as far as was possible without injuring the objects, and found to be platinum or one of the platinum group of metals, probably chiefly platinum. Petrie has reported in gold objects of this same dynasty similar hard, white specks, which he calls osmiridium ⁷ (a natural alloy of osmium and iridium), though no evidence is given for this and it is much more likely that they are largely platinum. Maspero states that certain Egyptian gold jewellery of the Eighteenth Dynasty contained platinum ⁸ and Mrs. R. Williams records similar particles in a number of instances in ancient Egyptian gold objects. ⁹

¹ W. M. Flinders Petrie, *The Arts and Crafts of Ancient Egypt*, p. 103.

² J. H. Breasted, *op. cit.*, II, 460, 462. ³ II, 471, 491, 509. ⁴ II, 494, 521.

⁵ G. A. Wainwright, in *Klio, Beitrage zur alten Geschichte*, 1913.

⁶ Berthelot, *Sur les métaux égyptiens*, in *Monuments et Mémoires Piot*, VII (1900), p. 132.

⁷ W. M. Flinders Petrie, *The Metals in Egypt*, in *Ancient Egypt*, 1915, p. 23.

⁸ G. Maspero, *The Dawn of Civilization*, 1901, p. 493.

⁹ C. R. Williams, *Gold and Silver Jewelry and Related Objects*, p. 27.

Platinum has never been reported as occurring in modern Egyptian gold, so far as is known, but it does occur as a trace in the nickel ore from St. John's Island in the Red Sea¹ and has been found in gold from the Sennar province of the Sudan² and it occurs, and was being worked on a small scale a few years ago, in western Abyssinia.³

SILVER⁴

Silver is found in nature in two conditions, namely, as metal and in the non-metallic state.

Native silver, which is practically pure, occurs only in small quantity, generally in the crystalline form, as needles, filaments, network, or arborescent shapes, though also, but more rarely, massive in nuggets and thin plates. Silver also occurs in practically all gold, sometimes in considerable proportion.

The principal ores of silver are silver sulphide, either alone or associated with sulphides of antimony or arsenic, and silver chloride. These, however, yield only about one-third of the world's supply of silver, the remaining two-thirds being obtained, not from silver ores proper, but from what are primarily lead, zinc and copper ores containing a very small proportion of silver (usually of the order of from 0.01 to 0.1 per cent), which may, therefore, be considered as low-grade silver ores.

So far as is known, neither native silver nor silver ores proper occur in Egypt, though all Egyptian gold contains silver, the proportion in that from the modern mines varying from 9.7 per cent to 23 per cent,⁵ and in ancient Egyptian objects of gold and electrum that have been analysed the proportion of silver has varied from probably a trace (this particular specimen having almost certainly been refined) to as much as 29 per cent,⁶ though there is no proof that the metal of all these was of Egyptian origin. Silver also occurs in very small amount in

¹ F. W. Moon, *Prel. Geog. Rept. on St. John's Island*, p. 16.

² F. Cailliaud, *Voyage à Méroé au Fleuve Blanc*, XII (1826), p. 19.

³ Kindly communicated by Mr. A. D. Home, District Commissioner, Gallabat.

⁴ A small part of this section has been taken from an article, *Silver in Ancient Times*, published by the author in *The Journal of Egyptian Archaeology*, XIV (1928).

⁵ See pp. 186-7.

⁶ See pp. 427-8.

both the local lead ore¹ and in the nickel ore.² In an Egyptian lead net-sinker, dating from about 1400 B.C., probably made from local lead, there was 0.03 per cent of silver,³ and 0.01 per cent in some galena from Gebel Jasus.⁴

Silver objects have been found in Egypt from as early as the predynastic period,⁵ but they were very rare until about the Eighteenth Dynasty, when silver began to be a little more plentiful, though it was not until Graeco-Roman times that it became fairly common. For example, in the Fourth Dynasty the objects from the tomb of Queen Hetepheres⁶ show that silver was then rarer and more precious than gold, since gold was employed lavishly to ornament the furniture, as also in the form of small dishes, a drinking cup, knives and razors, whereas the only silver consisted of twenty anklets (inlaid with turquoise,⁷ lapis lazuli and carnelian), which, although having an appearance of solidity, because they are rounded on the outside, are only shells of very thin metal. Even in the tomb of Tut-ankhamûn, some 1,500 years later, there were only a few silver objects, though others may have been stolen.

Petrie states that the silver employed in the predynastic period 'was obtained probably from Syria'⁸ (to which cause he attributes its scarcity^{8, 9}) and again that it 'could only be got by mining in North Syria,'¹⁰ but there is no evidence whatever for this, and the source of supply was almost certainly local until after the Egyptian conquests in Asia during the Eighteenth Dynasty. Thus the ancient records are silent as to where silver came from until the Eighteenth Dynasty, when it is stated

¹ See p. 200.

² F. W. Moon, *Prelim. Geog. Rpt. on St. John's Island*, p. 16.

³ J. Newton Friend, *The Silver Contents of Specimens of Ancient and Mediæval Lead*, in *Journal, Institute of Metals*, xli (1929), p. 106.

⁴ C. J. Alford, *Gold Mining in Egypt*, in *Journ. Inst. Mining and Metallurgy*, 1901, p. 13.

⁵ W. M. Flinders Petrie, *Prehistoric Egypt*, pp. 27, 43.

⁶ G. A. Reisner, *The Tomb of Queen Hetep-heres*, in *Bull. Mus. Fine Arts, Boston*, xxv (1927), special number.

⁷ This was originally described as malachite by Dr. Reisner, who, however, now accepts the author's identification of turquoise.

⁸ W. M. Flinders Petrie, *Prehistoric Egypt*, p. 27.

⁹ W. M. Flinders Petrie, *Social Life in Ancient Egypt*, p. 5.

¹⁰ W. M. Flinders Petrie, *The Metals in Egypt*, in *Ancient Egypt*, 1915, p. 16.

to have been received from Assur,¹ Kheta,² Naharin,³ Retenu,⁴ Senzar⁵ and Zahi,⁶ all countries in Asia, and in the Nineteenth Dynasty it came from God's Land⁷ (here manifestly from the context a country to the North of Egypt), Kheta⁸ and Naharin,⁹ again all Asiatic countries, but also from Libya,¹⁰ a country to the north-west of Egypt.

As already stated, neither native silver nor silver ores proper occur in Egypt, though silver is found in very small proportion in both the local lead ore and the local nickel ore. Since, therefore, there was no native silver and no ores that could be treated to obtain the metal, and since there is no evidence and very little probability that the Egyptians of predynastic and early dynastic times had the necessary metallurgical knowledge to enable them to separate minute proportions of silver from lead ores (though these were worked for galena to use as an eye-paint and also for smelting to obtain the metal), much less from nickel ores (which were not worked at all anciently), what then was the source of the ancient silver? It could not have been obtained from the local gold and electrum, though these contain considerable proportions, since the necessary knowledge of how to separate silver from gold was lacking, even as late as Greek times, as is proved by the method of refining gold (chiefly from silver) described by Agatharchides,¹¹ in which the silver was converted into chloride and rejected. In the author's opinion, there is no doubt that, both in Egypt and in western Asia, there were alloys of gold and silver, of the nature of electrum, so rich in silver that they were silver-white and that it was these alloys that constituted the first ancient silver, that is to say they were 'white gold,' which is what the Egyptians called silver. This seems to be proved by the fact that all the early silver from Egypt is in fact such an alloy and contains gold, sometimes in considerable proportion, the specimens of which analyses are available, containing from 1.2 per cent to 38.1 per cent of gold.¹²

That the ancient gold and electrum were natural products

¹ J. H. Breasted, *op. cit.*, II, 446.

⁴ II, 447, 491, 518, 820.

⁷ III, 116, 274.

¹¹ See p. 187.

² II, 485.

⁵ II, 584.

⁹ III, 434.

¹² See p. 428.

³ II, 482.

⁶ II, 459, 490.

¹⁰ III, 584.

⁸ III, 420.

that still occur in Egypt will generally be admitted, and it is not unreasonable to suppose, therefore, that the silver was also a natural product, though the fact that an alloy of gold and silver, containing so large a proportion of the latter as to have a white colour, is still to be found is not usually recognized. Nowadays, however, such an alloy would generally be classed as a poor quality gold and its true character might be masked by the manner in which it would be considered and reported. Anciently the case was different; silver was scarce and in consequence was several times the value of gold and hence it would have been the object of diligent search and even the smallest deposits found would have been highly prized and would have been worked until exhausted. That it still occurs, however, is proved by the results of the assay (by A. C. Claudet) of twenty-six specimens of modern Egyptian gold from quartz quoted by Alford.¹ When the ratio of silver to gold in these specimens is calculated it is seen that in fifteen instances this is one part or more of silver to one part of gold, the highest ratio being 3.3 parts of silver to one part of gold. All these specimens, therefore, would be silver-white, since a silver-gold alloy containing 50 per cent or more of silver has a white colour. Mellor mentions a specimen of natural silver-gold alloy from Norway that contained 28 per cent of gold and, therefore, by inference, 72 per cent of silver,² which also would be white.

Eventually, silver was obtained, as it is largely to-day, from argentiferous lead ores, which is proved, by the exploitation of the mines of Mount Laurion in Attica (Greece), certainly as early as the fifth³ and fourth centuries^{4, 5} B.C. and probably earlier. It is unlikely, however, that these, or indeed any Greek mines, were the first to be worked and probable that the earliest production of silver from an ore (which was certainly argentiferous lead ore) took place in western Asia, where such ores occur extensively. In Anatolia and Armenia there are many ancient silver mines, which unfortunately cannot be dated,

¹ C. J. Alford, *A Report on Ancient and Prospective Gold Mining in Egypt*, 1900, Appendix.

² J. W. Mellor, *Inorganic and Theoretical Chemistry*, III, p. 299.

³ Herodotus, VII, 144. ⁴ Xenophon, *Essay on the Revenue of Athens*, IV.

⁵ Aristotle, *Constitution of Athens*, XLVII.

the ores being chiefly argentiferous, galena associated with sulphide of zinc.¹ In Georgia and Caucasia there are also similar ores, though whether they were worked anciently or not is uncertain.² In Persia, too, lead ores containing silver are widely distributed, but again it is not known whether they were exploited anciently or not.^{3, 4}

Pliny states⁵ that 'The Egyptians stain silver,' and he goes on to say that 'strange to relate the value of the silver is enhanced when its splendour has been sullied. The preparation is as follows: one-third of a part of the finest Cyprian copper . . . is mixed with one part of silver and the same amount of live sulphur. The whole is heated in an earthen crucible luted with clay . . . 'Silver can also be tarnished with the yolk of a hard-boiled egg.'

The word 'stain' (*tinguit*) suggests some method of treating a silver object whereby it acquired a dark or black colour, particularly in view of the statement about tarnishing (*nigrescit*) silver by means of the sulphur compounds in egg-yolk, but the description given is not that of making a stain or varnish to be applied to silver, but for producing an alloy of silver and copper blackened by the sulphides of these metals and apparently it was this black alloy that was employed in place of pure white silver, a strange taste, as Pliny remarks. No instance of silver thus treated can be traced as having been found in connexion with ancient Egypt.

Silver Plating

The Egyptians early knew how to plate copper with silver, as is proved by a copper ewer of the Second Dynasty found by Brunton.⁶ Professor Thompson, reporting upon this, says, 'The material of which the ewer is made contains tin. Whether this is present in sufficient quantity to constitute a bronze'

¹ H. A. Karajian, *Mineral Resources of Armenia and Anatolia*, pp. 140-60.

² D. Ghambashidze, *Mineral Resources of Georgia and Caucasia*, pp. 44-9.

³ Moustafa Khan Fateh, *The Economic Position of Persia*, p. 32.

⁴ Geog. Section, Naval Intell. Division, Admiralty, London, *Geology of Mesopotamia and its Borderlands*, p. 69.

⁵ xxxiii, 46. ⁶ G. Brunton, *Qau and Badari I*, p. 67; Pl. XVIII (10).

⁷ Bronze may almost certainly be excluded at so early a date as the Second Dynasty.

cannot be determined without destroying the sample. The material is cold-worked and appears to have been hammered to shape from a sheet. There is a definite coating of either silver or tin on the outside of the ewer. The former is the more probable, though one cannot be sure without spoiling the vase. There are indications that this plating was done by hammering the other metal on the copper or bronze before the ewer was made. The spout appears to have been hammered on to the rest of the body.' This ewer was further examined by Professor H. B. Dixon, who stated that silver is certainly present on the surface of the copper as a very thin layer and tin absent, the silver having been put on either in the pure state or alloyed with copper. As an explanation of the method of plating employed, Brunton adopted a suggestion put forward by the author, that the technique might have been analogous to that employed for making the 'gold' thread required in the manufacture of the 'Holy Carpet' formerly sent annually by the Egyptian Government to Mecca. This so-called 'gold' thread, which was really silver thread covered with a thin coating of gold, was made as follows¹: A thick bar of silver was wrapped round with thin sheets of gold and heated in a small charcoal furnace, from which it was periodically removed and well rubbed with a thick agate rod, the gold eventually alloying with the silver, forming a thin, uniform, strongly and closely adherent coating. This was then passed through a series of draw-plates until thread of the required thinness was obtained, which had all the appearance of being gold though it was only silver plated with gold.

The principal use of silver anciently was for beads, jewellery, bowls and vases, though, like gold, it was also beaten into thin leaf and used for covering wood, as on one of the coffins of Yuya (Eighteenth Dynasty). One instance of the use of silver at an early date for soldering copper has already been given² as also an instance of its use for plating copper.

¹ A. Lucas and B. F. E. Keeling, *The Manufacture of the Holy Carpet*, in *Cairo Scientific Journal*, VII (1913), pp. 129-30.

² See p. 173.

TIN¹

The word 'tin' is often loosely used to designate both the metal and the ore, but in order to avoid ambiguity and misunderstanding, the term will here be restricted to its correct meaning of the metal.

In antiquity the principal use of tin was for making bronze, though occasionally it was employed alone. The early history of tin is very obscure and no evidence can be found to show when it was first discovered. The sequence of tin and bronze is also uncertain, though from the fact that the first recorded appearance of tin was in the form of its alloy bronze, as also from theoretical considerations, the probability is that bronze was made some considerable time before tin as an individual metal was isolated, just as brass (an alloy of copper and zinc) was known long before zinc itself was discovered. Either tin or tin ore, however, must have been used to produce bronze, of which tin is an indispensable constituent, though if the ore, as distinguished from the metal, were employed, it need not necessarily have been recognized at first as being essentially different from copper, all the knowledge required being a realization that ore from a certain place when added to copper ore produced an improved form of copper.

Although tin ore, so far as is known, does not occur in Egypt, the earliest use of tin, apart from bronze, that has been found is from Egypt and the earliest references to tin that are known are also possibly Egyptian. Thus the first objects of tin of which any records can be traced, namely a ring^{2, 3} and a pilgrim bottle,⁴ are from Egyptian graves of the Eighteenth Dynasty (1580 B.C. to 1350 B.C.). A ring, consisting of an alloy of tin and silver, is also known from the same period,⁵ and an ore of tin (the oxide) was employed in Egypt in small amount from

¹ Part of this section has been taken from an article (*Notes on the Early History of Tin and Bronze*) published by the author in *The Journal of Egyptian Archaeology*, xiv (1928).

² W. M. Flinders Petrie, *The Arts and Crafts of Ancient Egypt*, 1910, p. 104.

³ J. H. Gladstone, *On Metallic Copper, Tin and Antimony from Ancient Egypt*, in *Proc. Soc. Bibl. Arch.*, xiv (1892), p. 226.

⁴ E. R. Ayrton, C. T. Curelly and A. E. P. Weigall, *Abydos*, III, p. 50.

⁵ C. R. Williams, *Gold and Silver Jewelry and Related Objects*, pp. 29, 92.

the Eighteenth Dynasty onwards for imparting a white opaque colour to glass,^{1, 2} and such an oxide was found in the tomb of Tut-ankhamûn.³ After this in chronological order comes an object of tin having the outlines of a winged scarab, which probably dates from about 600–700 B.C.⁴: from the Roman period in Nubia there are two finger rings of tin,⁵ two bronze bowls that have been tinned⁵ and a bowl of pewter,⁵ an alloy of lead and tin; in the third century A.D. tin plates inscribed with magical charms are mentioned⁶; and in A.D. 572 there is a recipe for making solder from lead (80 per cent) and tin (20 per cent) for soldering the pipes of a bath.⁷

The earliest references to tin that can be found are three that occur in the Harris Papyrus,⁸ an Egyptian document of the Twentieth Dynasty (1200 B.C. to 1090 B.C.). The next references in chronological order are in Homer⁹ (ninth century B.C.), then another Egyptian reference of the Twenty-fifth Dynasty⁸ (712 B.C. to 663 B.C.), after which come four references in the Bible,¹⁰ one in Numbers (about fifth century B.C.), a doubtful one in Isaiah (either eighth or fifth century B.C.) and two in Ezekiel (sixth century B.C.), then Herodotus¹¹ (fifth century B.C.), Diodorus Siculus¹² (first century B.C.), Julius Caesar¹³ (first century B.C.), Strabo¹⁴ (first century B.C. to first century A.D., in one instance quoting Posidonius of the second to first

¹ B. Neumann and G. Kotyga, *Z. für angew. Chem.*, 1925, pp. 776–80, 857–64.

² H. D. Parodi, *La verrerie en Égypte*, pp. 34, 45.

³ A. Lucas, *Appendix II*, in *The Tomb of Tut-ankh-Amen*, Howard Carter, III, pp. 176–7.

⁴ A. H. Church, *Chemical News*, 1877, p. 168.

⁵ L. C. Woolley and D. R. Randall-MacIver, *Karanog*, III, p. 67.

⁶ F. G. Kenyon, *Greek Papyri in the British Museum*, I, pp. 91, 93, 97, 99.

⁷ B. P. Grenfell and A. S. Hunt, *The Oxyrhynchus Papyri*, VI, pp. 268–9.

⁸ J. H. Breasted, *Ancient Records of Egypt*, IV, 245, 302, 385, 929. The meaning of the word translated 'tin' is, however, stated to be doubtful.

⁹ *Iliad*, XI, 25, 34; XVIII, 474, 565; XX, 271; XXI, 592; XXIII, 503, 561.

¹⁰ *Numbers*, 31, 22; *Isaiah*, 1, 25 (the R.V. gives the alternative reading 'alloy'); *Ezekiel*, 22, 18 and 20; 27, 12.

¹¹ III, 115.

¹² V, 2.

¹³ *De Bello Gallico*, V, 12.

¹⁴ III, 2, 9; III, 5, 11; XV, 2, 10.

century B.C.), Pliny¹ (first century A.D.) and other classical writers.

In the first century A.D. tin was being shipped by way of Egypt to Somaliland and India,² but from where it was obtained is not stated.

Tin does not occur naturally in the metallic condition, the form in which it is found in nature being in the combined state as a mineral, the principal and only tin mineral of importance being the oxide (cassiterite or tinstone), though a sulphide combined with the sulphides of copper and iron (stannite, stannine or tin pyrites) is also found in small quantity in certain localities.

Metallic tin is one of the easiest metals to produce and it may be obtained by simply heating the oxide with charcoal, this being the fuel employed anciently and the fuel generally used for smelting until about the eighteenth century A.D. The metal, however, cannot be produced from the sulphide by any such simple means, which is proof that this ore was not employed anciently as a source of tin.

Tin oxide occurs in two forms, one in veins (lodes), always in granite or granitic rocks and occasionally associated with copper ore, and the other as pebbles, gravel or sand, derived from the disintegration of rocks bearing vein ore, the debris from which has been carried and deposited by water.

Tin ore (cassiterite) is heavy and usually dark brown or black in colour and, except the weight, there is nothing to suggest that it is a metallic compound. It is frequently found in the same alluvial gravels as gold, and since both are obtained by the same method, namely by washing away the lighter material with running water, it is exceedingly probable that when gold was being searched for the heavy tin oxide, which, however, is not nearly so heavy as gold, would be noticed, and it seems likely that the alluvial ore was discovered in this manner. On account of this association with gold, and also because the alluvial ore occurs in more accessible places and is more easily mined than the vein ore, it was probably alluvial ore that was worked first deliberately as a separate ore.

Claims have been made for Europe, Africa and Asia respec-

¹ IV, 30, 34, 36; VII, 57; XXXIV, 47, 48.

² W. H. Schoff, *The Periplus of the Erythraean Sea*, pp. 33, 42, 45.

tively as the place where tin was first discovered and the home therefore probably of bronze.

The claim for the European origin of tin¹ and bronze² has not found general support and, in the author's opinion, there is neither evidence nor probability that tin was being mined and bronze made in Central Europe as early as the Fourth Dynasty (about 2900 B.C. to 2750 B.C.), the possible date of two Egyptian bronze objects,³ nor even at the time of the Middle Kingdom (about 2000 B.C.), from which period a number of bronze objects have been found in Egypt.⁴ That the still earlier Asiatic bronze should have come from Europe is even more unlikely.

With respect to Africa, although tin ores occur plentifully,⁵ it is inconceivable that important materials, such as tin (or tin ore) and bronze, should have been traded in quantity for centuries to Egypt, and possibly through Egypt to Asia and Europe, without leaving some evidence of the traffic or some traces or knowledge of either tin or bronze on the way, and no such evidence or traces are known. Also, this would not explain the possession of bronze in Mesopotamia at a date considerably earlier than it was known in Egypt, unless the Mesopotamian bronze did not pass through Egypt, but reached that country by sea, and that any trade, much less a regular trade, should have been carried on between East Africa and the Persian Gulf as early as about 3500 B.C. to 3200 B.C., which is the approximate date of the earliest bronze found in Mesopotamia,⁶ is most improbable.

From the evidence at present available there seems no doubt that the home of both tin and bronze was in western Asia and it has been thought that the special locality was possibly in north-east Persia, where both tin and copper ores are known to occur.⁷ Wainwright, however, has just published an important article in which he shows that a likely early source of tin and

¹ W. M. Flinders Petrie, *Medum*, p. 44.

² W. M. Flinders Petrie, *The Arts and Crafts of Ancient Egypt*, 1910, p. 101.

³ See p. 177.

⁴ See p. 178.

⁵ A. Lucas, *Notes on the Early History of Tin and Bronze*, in *Journal of Egyptian Archaeology*, xiv (1928), pp. 100-1.

⁶ See p. 175.

⁷ A. Lucas, *op. cit.*, pp. 100, 108.

bronze, particularly of the Egyptian supply, was the Kasrwan district of Syria,¹ which is situated a little to the north-west of the modern town of Beyrut, to the occurrence of tin in which the author drew attention several years ago,² without, however, realizing its importance. Wainwright shows that both tin ore and copper ore occur in the mountains of the Kesrwan district, through which flow two rivers, the Nahr Ibrahim and the Nahr Feidar (the ancient Adonis and Phaedrus) which enter the sea near the site of the ancient town of Byblos, which was on the banks of the Adonis and was *the* port for Egyptian trade from at least as early as the First Dynasty.

No evidence is known of either ancient or modern mining in the Kesrwan Mountains, but the country was prospected some years ago by two Australian mining engineers, who applied for the right to mine tin, copper and silver ores, which, therefore, they must have been satisfied existed in quantity, the work, however, being suspended on the outbreak of war and never resumed.³ Wainwright suggests that fragments of tin ore or copper ore, or both, may have been brought down by the two rivers mentioned, the Adonis having a strong current all the year round and the Phaedrus a 'considerable flood after heavy rains,' though it dries up during the summer. This dried river bed would have been a most likely place for discovering and collecting any fragments of ore there may have been, and it should not be forgotten that in the West, where alone there is early written evidence of tin working, the ore, which was alluvial, was derived from the dried beds of ancient water-courses. Thus, referring to Spain-Portugal, Strabo (first century B.C. to first century A.D.) quotes Posidonius⁴ (second to first century B.C.) for the statement that the earth in which the tin ore occurred was 'brought down by the rivers: this the women scrape up with spades and wash in sieves . . .' and Pliny (first century A.D.) says⁵ of the same Spanish-Portuguese tin ore that 'It is a sand found on the surface of the earth, and

¹ G. A. Wainwright, in *Journal of Egyptian Archaeology*, xx (1934), pp 29-32.

² A. Lucas, in *Journal of Egyptian Archaeology*, xiv (1928), p. 100.

³ I. M. Toll, *The Mineral Resources of Syria*, in *Eng. and Mining Journal*, cxii (1921), p. 851.

⁴ III, 2, 9.

⁵ xxxiv, 47.

of a black colour, and it is only to be detected by its weight. It is mingled with small pebbles, particularly in the dried beds of rivers.' Manifestly, therefore, the ore described by both these writers was alluvial.

Diodorus, writing with reference to the inhabitants of Cornwall, states¹ that 'These are the people that make the tin, which with a great deal of care and labour they dig out of the ground; and that being rocky, the metal is mixed with some veins of earth, out of which they melt the metal and then refine it.' Although at first sight this description might suggest the mining of vein and not alluvial ore, it was almost certainly the latter that was meant, since in certain districts in Cornwall the alluvial gravels are not on the surface, but in one place, for example, they are beneath some 50 feet of sand and silt and in another place they are covered with peat, gravel and sand to a depth of 20 feet.² Also, all the available evidence points to 'tin streaming,' as it was termed, having been a much older industry in Cornwall than the mining of vein ore.

In view of the probability, as shown by Wainwright, that some at least of the early tin ore found in the East was alluvial and was possibly accompanied by copper ore (almost certainly malachite, the usual ore of surface copper deposits, which would have been well known at the time and recognized as yielding copper when smelted), the explanation previously given by the author to account for the discovery of tin and bronze³ may be much simplified. Although it was recognized that 'it was probably alluvial ore that was worked first deliberately as a separate ore,'³ it was assumed that bronze was first made accidentally by smelting associated ores of copper and tin, both derived from veins,⁴ because no association of copper ore and alluvial tin ore was known, but it is now suggested that the sequence of events may have been much as follows: First, the discovery of alluvial tin ore, possibly on the banks or in the bed of either the Adonis or Phaedrus, or both, and probably during a search for gold.⁵

Second, the realization that the comparatively heavy tin ore

¹ v, 2.

² G. M. Davies, *Tin Ores*, pp. 28, 29.

³ A. Lucas, *op. cit.*, p. 98.

⁴ A. Lucas, *op. cit.*, p. 107.

⁵ See p. 211.

might be metalliferous, possibly even a kind of copper ore, and the consequent smelting of it, either alone, when tin would have been discovered, or more probably mixed with copper ore, when bronze would have been made.

Third, when the alluvial tin ore first found, which probably only occurred in comparatively small amount, was becoming exhausted, search was made for other supplies and the sources in Spain-Portugal, Cornwall, Brittany and elsewhere manifestly became known and eventually, at a very much later date and in some places only, the parent veins (lodes) from which some of the alluvial ore had originally been derived were tracked down and worked.

It should be pointed out that the hypothesis of the possible discovery of tin ore and bronze in a district in such close touch with Egypt, as was the neighbourhood of Byblos, leaves unexplained the fact of the knowledge of bronze in Mesopotamia at a much earlier date than in Egypt, unless other and earlier sources of tin ore were also known.

MINERALS

The dictionary definition of a mineral is 'a substance obtained by mining,' but the word is here used, not in this wide sense, but with a very restricted meaning, since the most important minerals, namely, the metals and their ores, have already been dealt with, and certain other mineral substances, such as building stone, ochres, orpiment, precious, semi-precious and other stones, either have been, or will be, separately described. The minerals to be discussed are alum, cobalt compounds, emery, graphite, manganese compounds, mica, natron, salt and sulphur.

ALUM

So far as can be ascertained, alum has never been discovered in connexion with ancient Egypt, and the evidence for its use is entirely circumstantial, namely, that alum occurs in Egypt; that it was mined anciently and that it was almost certainly the mordant to which Pliny refers that was employed in Egypt

for fixing the colours during the dyeing of cloth.¹ These statements will now be proved.

Alum occurs in the Oases of Dâkhla and Kharga, which are situated in the desert west of the Nile valley ; in Dâkhla it is 'widely distributed in small quantities'² ; in Kharga there are 'ancient mines of the most extensive description'³ ; 'hills . . . literally honeycombed with ancient workings'³ ; 'Huge dump heaps'³ and 'The extent and magnitude of the underground workings prove that whatever the mineral mined, it was a substance of considerable value in those days ; and an examination of the blind termination of the tunnels occasionally reveals the presence of very thin seams of aluminium sulphate, which . . . we must conclude was the substance sought.'³ Miss Caton-Thompson and Miss Gardner state that 'miles of outlying foothills and desert floor alike were seen to be riddled with shallow workings, giving the ground the appearance of having been shelled.'⁴ 'Alum seems most likely to be the mineral sought.'⁴

Some part at least of this mining is undoubtedly comparatively modern, thus Maqrîsî states⁵ that in Arab times 1,000 *kantars* (44 tons) of alum were sent annually from the Oases to Cairo ; another Arab writer says⁶ that the receipts from the alum mines formed part of the Government revenue and in 1809 Hamilton wrote⁷ : 'The trade of Goubanieh, which is a few miles below As Souan, consists in the fitting out annually a caravan of fifty camels for the purpose of procuring alum from a low spot in the Desert, ten or eleven days' journey South-West of the Cataracts. It is found in a single stratum from two to fifteen inches in depth covered with a layer of dry sand about half a foot thick and resting on a bed of moist

¹ xxxv, 42.

² H. J. L. Beadnell, *Dakhla Oasis, Its Topog. and Geology*, pp. 100-1.

³ H. J. L. Beadnell, *An Egyptian Oasis*, pp. 220-3.

⁴ G. Caton-Thompson and E. W. Gardner, *The Prehistoric Geography of Kharga Oasis*, in *The Geographical Journal*, LXXX (1932), p. 372.

⁵ Maqrîsî, *Description Topographique et Historique de l'Égypte*, in *Mém. de la mission arch. franc. au Caire*, 1900, pp. 17, 691, 697, 698.

⁶ Stanley Lane-Poole, *A History of Egypt in the Middle Ages*, p. 304.

⁷ W. Hamilton, *Remarks on Several Parts of Turkey, Part I, Aegyptiaca*, p. 428.

sand. The alum when taken is broken in pieces, dried in the sun and at Goubanieh is sold at seven *pataques* the *ardeb*.'

But this was not the earliest mining, as Herodotus (fifth century B.C.) says¹ that King Amasis (569 to 526 B.C.) sent from Egypt a thousand *talents*' worth of astringent earth (almost certainly alum) as a contribution towards the rebuilding of the temple at Delphi and that the Greek dwellers in Egypt sent a further twenty *minae* worth. Egyptian alum was also known to the Romans of Pliny's day (first century A.D.) since this writer, when enumerating the different sources of alum, includes Egypt and states that the Egyptian alum was 'the most esteemed.'² Miss Caton-Thompson and Miss Gardner state³ that 'Sherds collected in field examination of mining areas . . . confirmed their Roman date.' Egyptian alum is also mentioned in a Greek papyrus found in Egypt,⁴ but unfortunately undated.

At the present time, alum is employed, both as a mordant in dyeing and as a medicine, and Pliny refers to its use for both these purposes² and, therefore, when he also mentions the use in Egypt for dyeing cloth of what is certainly a mordant,⁵ it is not unreasonable to suppose that he was referring to alum, more especially as alum occurs in Egypt, where it had been mined for several centuries at least before Pliny wrote.

COBALT COMPOUNDS

The chief value of cobalt compounds is the deep permanent blue colour of some of them, on account of which they are highly esteemed as pigments by artists and are also employed to impart a blue colour to glass. So far as is known, cobalt blue was not employed as a pigment in ancient Egypt, although two instances of its alleged use have been reported. One of these is the statement by Toch⁶ that he had found cobalt blue pigment on the walls of the Fifth Dynasty tomb of Per-neb.

¹ II, 180.

² xxxv, 52.

³ G. Caton-Thompson and E. W. Gardner, *op. cit.*, p. 372.

⁴ B. P. Grenfell and A. S. Hunt, *The Oxyrhynchus Papyri*, II (1899), pp. 134-6.

⁵ xxxv, 42.

⁶ M. Toch, *The Pigments from the Tomb of Perneb*, in *Journ. Ind. and Eng. Chemistry*, 1918, p. 118.

This has recently been shown to be a mistake, all the blue pigment in the tomb being the well-known blue frit coloured by means of a copper compound.¹ The other instance of the supposed use of cobalt blue is the statement by Wiedemann that Hofmann had found a blue pigment of the time of Ramesses III (Twentieth Dynasty) to be a cobalt colour.² This, however, Mrs. Williams finds to be an error, Hofmann's reference being not to the use of cobalt blue as a pigment, but to the employment of smalt,³ an artificial preparation of the nature of glass coloured by a cobalt compound, which, although it might be used as a pigment, might equally well have been for colouring glass.

The occasional use of cobalt compound for colouring blue glass has been dealt with in connexion with glass, the earliest date from which it is reported being the Eighteenth Dynasty.⁴

Cobalt ores, so far as is known, do not occur in Egypt, the only cobalt compounds yet found being traces in the alum minerals of both Kharga and Dâkhla Oases^{5, 6} and in the nickel ore of St. John's Island in the Red Sea,⁷ these occurrences being certainly unknown anciently and the compounds presenting almost insuperable difficulties of extraction. Any cobalt compound used, therefore, must have been imported, possibly from Persia or the Caucasus region, in both of which places cobalt ores occur. Traces of cobalt compounds have also occasionally been found in ancient Egyptian copper and bronze objects and in a specimen of ancient slag from Sinai,⁸ which suggests that they may be present as traces in the Egyptian copper ore.

EMERY

Emery is a greyish-black variety of corundum and consists essentially of oxide of aluminium, though it also contains an

¹ C. R. Williams, *The Decoration of the Tomb of Per-neb*, p. 27, n. 34.

² A. Wiedemann, *Cobalt in Ancient Egypt*, in *Proc. Soc. Bibl. Arch.*, xv (1892-3), pp. 113-14.

³ C. R. Williams, *op. cit.*, p. 27, n. 29.

⁴ See p. 122.

⁵ H. J. L. Beadnell, *An Egyptian Oasis*, p. 222.

⁶ W. F. Hume, *Explan. Notes to the Geol. Map of Egypt*, p. 40.

⁷ F. W. Moon, *op. cit.*, p. 16.

⁸ J. Sebelien, *Early Copper and its Alloys*, in *Ancient Egypt*, 1924, p. 10.

admixture of oxide of iron ; its hardness is next to that of the diamond and when finely powdered it is largely used as an abrasive.

Beyond a statement that some of the sand at Aswan contains 15 per cent of emery,¹ which has never been confirmed, there is no evidence of its occurrence in Egypt, but it is found plentifully in Asia Minor and in several of the Aegean islands.

A few objects, stated to be of emery, which probably some at least of them are (though this does not seem to have been confirmed by analysis, but assumed because the material scratches glass) mostly dating from predynastic and early dynastic times have been found in Egypt : these include a plummet,^{2, 3} a vase,⁴ a tool,⁵ three small blocks ^{2, 3} (thought to have been used for polishing beads because of their grooved condition), a piece ⁶ and several hones,⁷ the date of the latter being unknown. It is often stated that emery was employed in ancient Egypt as an abrasive with drills and saws for working hard stones and, although some abrasive powder must have been used, it has never been proved that the material was emery, which in the author's opinion is most improbable and its use for carving into various objects seems a contra-indication. This alleged use of emery as an abrasive has already been fully dealt with in connexion with stone working.⁸

GRAPHITE

Graphite (often termed plumbago or blacklead) is a soft, black or dark grey substance consisting largely of carbon, the proportion of which usually varies from about 50 to 97 per cent, the admixture being clay and other impurities. It is

¹ G. A. Wainwright, *Balabish*, p. 38.

² W. M. Flinders Petrie and J. E. Quibell, *Naqada and Ballas*, pp. 29, 44, 45, 48.

³ W. M. Flinders Petrie, *Prehistoric Egypt*, pp. 41-2.

⁴ J. E. Quibell and F. W. Green, *Hierakonpolis*, II, p. 50.

⁵ J. E. Quibell, *Archaic Objects*, in *Cat. Gén. du Musée du Caire*, p. 304.

⁶ D. Randall-MacIver and A. C. Mace, *El Amrah and Abydos*, p. 49.

⁷ British Museum, *A Guide to the Third and Fourth Egyptian Rooms*, 1904,

p. 43.

⁸ See pp. 72-3.

widely distributed in nature and occurs in Egypt in certain schists in the eastern desert, especially in the gold-mining areas¹ and in the beryl-mica-schists at Wâdi Um Deba'a² and in the quartz veins of the gold-bearing rocks.

A few specimens of graphite have been found in connexion with ancient Egypt, one of Eighteenth Dynasty date by Petrie in a house at Gurob³; a graphite bead and a small lump in a shell by Steindorff at Aneiba in Nubia⁴ and a number of small pieces by Reisner at Kerma in the Sudan,⁵ where it was used for blackening certain pottery. The Gurob specimen was analysed by Dr. Ainsworth Mitchell and proved to be very impure, containing much siliceous matter and only 39 per cent of carbon.⁶

MANGANESE COMPOUNDS

Manganese occurs in nature chiefly combined with oxygen as oxides, which are widely distributed in Egypt, the Nubian sandstone, for example, being permeated with veins of these compounds: they also occur plentifully in Sinai, and from one area alone 1,084,699 metric tons were extracted during the years 1917 to 1928 inclusive.⁷

Petrie mentions three oxides of manganese, namely, wad (Twelfth Dynasty), pyrolusite (Eighteenth Dynasty), and psilomelane (undated) as having been found on ancient sites, but not known to have been used.⁸

Oxides of manganese were employed in ancient Egypt to impart a purple colour to glaze and glass, but their use for any other purpose is unknown. The earliest date recorded for the use of manganese compounds for colouring glass is the Eighteenth Dynasty,⁹ but their use for colouring glaze was much earlier,

¹ W. F. Hume, *A Prelim. Report on the Geol. of the Eastern Desert*, p. 40.

² W. F. Hume, *Geology of Egypt*, II (Part I), pp. 112, 114, 162, 165.

³ W. M. Flinders Petrie, *Ancient Egypt*, 1927, p. 58.

⁴ Not yet published. Examined by the author.

⁵ G. A. Reisner, *Excavations at Kerma*, IV-V, p. 290.

⁶ C. A. Mitchell, *Graphites and other Pencil Pigments*, in *The Analyst*, XLVII (1922), p. 380.

⁷ Mines and Quarries Department, *Report for 1928*, p. 12.

⁸ W. M. Flinders Petrie, *Descriptive Sociology, Ancient Egyptians*, p. 49.

⁹ See p. 121.

though the precise date is uncertain. These oxides were required anciently in such small quantity and they occur so plentifully in the country, that it is highly improbable there was any importation from abroad. Ancient workings have been reported from one locality in the eastern desert.

MICA

The micas are a group of minerals specially distinguished by their ready cleavage into thin plates: chemically they consist of silicates of aluminium combined with compounds of iron, magnesium, potassium or sodium; they occur as essential constituents of many rocks, such as granite and gneiss, and are very plentiful in Egypt, and mica, in the form of small glittering scales, is often present in Nile silt and in many Egyptian clays, from which sources it finds its way into some of the local pottery and may frequently be seen in both ancient and modern ware.

Mica was used occasionally in Egypt in predynastic times,^{1, 2} though for what purpose is unknown; mica mirrors of archaic date have been found in Nubia³ and in the Egyptian colony of Middle Kingdom date at Kerma in the Sudan small pieces of mica were employed for decorating caps.⁴

NATRON⁵

Natron is a naturally occurring compound of sodium carbonate and sodium bicarbonate. At the present time it is found in three localities in Egypt, two (the Wâdi Natrûn and the Behêra province) in Lower Egypt and one (El-Kâb) in Upper Egypt.

The Wâdi Natrûn is a depression in the Libyan desert, some 40 miles to the north-west of Cairo; it is about 21 miles long,

¹ W. M. Flinders Petrie, *Prehistoric Egypt*, p. 44.

² W. M. Flinders Petrie and J. E. Quibell, *Naqada and Ballas*, p. 45.

³ C. M. Firth, *Arch. Survey of Nubia, Report for 1910-1911*, pp. 201, 209, 210.

⁴ G. A. Reisner, *Excavations at Kerma*, IV-V, pp. 272-80.

⁵ This section has been taken from an article, *The Occurrence of Natron in Ancient Egypt*, published by the author in *The Journal of Egyptian Archaeology*, XVIII (1932).

and at the bottom there is a string of lakes, the water surface of which is about 76 feet (23 metres) below sea level and the number of which fluctuates with the season. During, and for several months after, the Nile flood (which usually begins at Cairo about the end of June and generally reaches its maximum in September, often in the latter half), when there is a considerable increase in the water supply entering the Wâdi, and when, on account of the lower temperature during the latter part of the period evaporation has decreased, there were a few years ago, when the author stayed in the Wâdi on several occasions, 12 lakes.¹ In summer there are always fewer than in winter, as some of the smaller and shallower ones dry up during the hot weather. Lakes varying in number from 7 to 16 are mentioned by different writers about the end of last century,² though at the beginning of the century there were apparently only 6.³ At a still earlier date, however, there would seem to have been only either one or two lakes. Thus in 1780 Sonnini mentions two,⁴ which he says became merged into one during the winter; in 1849 Gmelin describes one 'pit,'⁵ as he terms it, but at what time of the year is not stated.

The natron in the Wâdi Natrûn occurs dissolved in the lake water—from which a thick layer has gradually been deposited at the bottom of some of the lakes—and also as an incrustation on the ground adjoining many of the lakes. The amount present is very considerable, although the Wâdi has been the source, not only of the principal Egyptian supply, but also of a small export trade, for several thousands of years.

About 30 miles due north of the Wâdi Natrûn, in the Behêra province, and some 14 miles to the west of the ruins of the ancient city of Naucratis, there is another, but much smaller, depression, slightly below sea level, in which also are a number of shallow lakes containing natron, the largest having an area

¹ One of these lakes was largely, if not wholly, caused by the waste water from the factory.

² A. Lucas, *Natural Soda Deposits in Egypt* (1912), p. 2.

³ General Andréossy, *Mémoire sur la vallée des lacs de natroun*, in *Description de l'Égypte*, I (Paris, 1809), État moderne, p. 281.

⁴ C. S. Sonnini, *Travels in Upper and Lower Egypt* (1780), trans. H. Hunter, II (1807), p. 139.

⁵ L. Gmelin, *Handbook of Chemistry*, trans. H. Watts, III (1849), p. 78.

of between 200 and 300 acres. In September each year the level of the subsoil water, owing to the general rise of the subsoil water of the Delta and the infiltration from neighbouring canals that run full during the Nile flood, begins to rise and manifests itself in such a manner that by December the permanent lakes have increased in size and other temporary shallower ones have been formed. During the summer the area partly dries up, leaving the natron in an easily accessible form. The amount of available material, though large is very much less than that in the Wâdi Natrûn.¹ These deposits were known to Sonnini in 1780, who rightly places them near Damanhûr²; at one time they were considered worked out, but during the past twelve years they have been exploited again to a small extent. This district is generally called either Barnugi or Harrâra after two of the lakes, which are named from neighbouring villages.

The El-Kâb natron deposits have been described by Schweinfurth³ and very briefly also by Schweinfurth and Lewin⁴ and by Somers Clarke.⁵ Schweinfurth, who gives a map of the neighbourhood of El-Kâb, shows five different localities where natron occurs, which he distinguishes as (a) the northern natron valley, (b) the northern natron plain, (c) the southern natron valley, (d) a natron efflorescence, and (e) the southern natron-salt plain. The natron is readily accessible, as the distance of the deposits from the river is only from about two kilometres to about seven kilometres.

El-Kalkashandî, an Arab writer who died at the beginning of the fifteenth century A.D., describes two other natron deposits,⁶ one of about 100 acres in extent at Tarâbiya, near Behnesah, in Upper Egypt, which he states had been worked since the time of Ibn-Tûlûn (A.D. 835-884) and which yielded an annual

¹ This description was kindly communicated by Dr. H. Sadek, Controller Mines and Quarries Department, Cairo.

² C. S. Sonnini, *op. cit.*, I, p. 324.

³ G. Schweinfurth, *Die Umgegend von Schaghab u. El-Kab (Ober-Ägypten)*, in *Zeitschrift der Gesellschaft f. Erdkunde zu Berlin* (1904), pp. 575-9.

⁴ G. Schweinfurth and L. Lewin, *Beiträge z. Topographie u. Geochemie des ägyptischen Natron-Tals*, in *op. cit.*, xxxiii (1898), pp. 1-25.

⁵ Somers Clarke, *El-Kâb and its Temples*, in *Journal of Egyptian Archaeology*, viii, p. 17.

⁶ S. Lane-Poole, *A History of Egypt in the Middle Ages* (1901), p. 304.

revenue of more than £50,000, and the other in the Fâkûs district in the Eastern Delta. These places are not now known as sources of natron.

In the ancient Egyptian records the natron deposits both of the Wâdi Natrûn¹ and of El-Kâb² are referred to, but so far as can be ascertained the Barnugi deposit is not mentioned. In the reign of Ramesses III (1198-1167 B.C.) natron gatherers of Elephantine are named.³ This seems a most unlikely place for natron to occur in workable quantity and there is no evidence of any to-day. May it be that the natron and salt (which is also mentioned) were found, not on the island, but in the vicinity, and that the gatherers lived at Elephantine or were attached to a temple there? In the reign of Tuthmosis III (1501-1447 B.C.) natron is enumerated among the articles of tribute received from Retenu (Syria).⁴

The classical writers, Strabo⁵ (first century B.C. to first century A.D.) and Pliny⁶ (first century A.D.), both mention natron deposits in Egypt. The former, in his description of a journey by boat from the coast to Memphis (apparently from Schedia by canal to the Canopic branch of the Nile and then by river) refers to two pits that furnished natron in large quantities, which he states were situated (as was also the Nitriote Nome) beyond (above, or south of) Momemphis and near to Menelaus. Then he goes on to say that on the left in the Delta was Naucratis and that at a distance of two *schœni* from the river was Sais. The question that arises is whether the natron pits were those of the Wâdi Natrûn or those of Barnugi. This could be settled at once if the precise position of either Momemphis or of Menelaus were known, but unfortunately neither of these places can be fixed with certainty. Parthey,⁷ Perthes⁸ and Dümichen⁹

¹ H. Gauthier, *Dictionnaire des noms géographiques contenus dans les textes hiéroglyphiques*, v, p. 56. H. Brugsch, *Dictionnaire géographique de l'Ancienne Égypte* (1879), pp. 150, 496-7. A. Erman, *The Literature of the Ancient Egyptians*, trans. A. M. Blackman, pp. 116, 117, 120.

² H. Gauthier, *op. cit.*, III, p. 99. H. Brugsch, *op. cit.*, pp. 45, 355.

³ J. H. Breasted, *op. cit.*, IV, 148. ⁴ II, 518. ⁵ XVII, I, 22, 23.

⁶ XXXI, 46.

⁷ G. Parthey, *Zur Erdkunde des alten Aegyptens* (1859), Maps i, ii, viii, xv, xvi.

⁸ J. Perthes, *Atlas Antiquus* (1897), Tab. 3.

⁹ J. Dümichen, *Zur Geographie des alten Ägypten* (1894), Map viii.

all show Momemphis well south of Naucratis, and Parthey shows Menelaus south of Momemphis. If these maps are correct the natron pits must have been those of the Wâdi Natrûn. The evidence for assigning the positions, however, is not given, but it may have been that the Barnugi deposit was not known to these cartographers and that they therefore fixed Momemphis and Menelaus with reference to the only natron deposit with which they were acquainted, namely that of the Wâdi Natrûn, and if so, then to appeal to these maps is to argue in a circle. Strabo's allusion to Naucratis and Sais immediately following his mention of Momemphis and Menelaus is ambiguous, but seems to be unconnected with his reference to the position of the natron pits, which, if near Naucratis, must have been those of Barnugi. Since there are two natron deposits in the same district and since Strabo only mentions one, which he states contained large quantities of natron, it seems likely that this should be the larger and more important of the two, namely that of the Wâdi Natrûn.

With reference to Barnugi, Evelyn White wrote that 'There is strong evidence to show that Barnugi is the Coptic Pernoudj, and the latter is certainly Nitria. Barnugi then would be the modern representative of the famous Nitria (not the Wadi el Natrun). Ancient authors clearly show that natron was obtained in the N.W. Delta in the region of Naucratis—not far distant.'¹

Pliny states² that in Egypt natron (*nitrum*) used to be found (*nitrariae . . . tantum solebant esse*) only near Naucratis and Memphis. The position of the first-mentioned deposit would fit that of Barnugi and, if so, then by exclusion the second would be that of the Wâdi Natrûn, since only two deposits are known in this locality. It is true that the Wâdi Natrûn is not very close to Memphis, but it is difficult to believe that this important source should be ignored in favour of some small and insignificant place nearer to Memphis, even if such existed, which is doubtful. Pliny's whole account of natron in Egypt, however, is very confused and often unintelligible. The natron from near Memphis is described as being inferior

¹ Private letter (dated 14. i. 1920) to Dr. W. F. Hume, who has kindly allowed me to make use of it.

² XXXI, 46.

to that from near Naucratis because the heaps petrify and are turned into rock, from which vessels are made ; and it is further stated that the material is often melted and heated with sulphur—though for what purpose is not mentioned.

No analyses of the Barnugi natron can be traced, but it is almost certainly not so good as the best quality from the Wâdi Natrûn. Natron, from whatever source obtained, if stacked in heaps for a long period and exposed to occasional slight rain would become consolidated, but never very hard and it is conceivable, though improbable, that a few small vessels might have been made as curiosities from such natron. That natron was ever heated with sulphur is highly improbable.

Pliny states, too,¹ that natron was prepared artificially in Egypt, much in the same manner as salt, the difference being that to make salt sea water was used, while to make natron the water employed was that of the Nile. From this account, which is largely wrong, and most misleading, especially in the analogy to sea water, it would seem that Pliny had some very confused idea of the manner in which natron occurs in Egypt, namely as a deposit in certain low-lying areas, which become flooded soon after the annual rise of the Nile, by reason of the infiltration water (either directly from the river or from canals or other sources fed by the river) that finds its way into them. The Nile water, however, does not, and never did, yield natron on evaporation.

It is suggested that the confusion may have originated in the following manner. When sea water evaporates, salt is left, and when the seepage water (either direct or indirect) from the Nile that finds its way into certain depressions evaporates, natron is left. Hence, at first sight, the two phenomena might appear to be similar, though they are fundamentally different. In the case of sea water, the salt is in solution in the water, and is left as a dry deposit when the water evaporates ; whereas in the case of the Nile seepage, the natron exists not in the water, but in the low-lying ground into which the water penetrates, having slowly accumulated there as the result of chemical reactions that have taken place in the soil during the course of long ages ; all that the water does is to dissolve the natron

¹ xxxi, 46.

already present and to bring it to the surface, where it is left when the water evaporates. Pliny's reference to the hasty collection of the natron if rain falls, for fear it should be redissolved, is suggestive of the Barnugi deposit, rather than that of the Wâdi Natrûn, since in the latter the rainfall is insignificant and does not seriously affect the natron, while at Barnugi the amount of natron is less and the rainfall greater, and in the autumn, before the natron is gathered, there might be sufficient rain to flood the area that had dried during the summer and so spoil the harvest.¹

In ancient Egypt natron was used in purification ceremonies,² especially for purifying the mouth³; for making incense⁴; for the manufacture of glass,⁵ glaze, and possibly the blue and green frits used as pigments, which may be made either with or without alkali, but which are more easily made if alkali is present; for cooking⁶; in medicine⁷ and in mummification.

During the Ptolemaic period natron was a royal monopoly⁸; in Arab times it was a considerable source of revenue to the Government⁹ and at the present day a small royalty is paid on all that is extracted.

As found in Egypt, natron always contains sodium chloride

¹ Early rain at the Lake Mareotis salt works near Mex limits considerably the amount of available salt.

² J. H. Breasted, *op. cit.*, IV, 865; A. M. Blackman, *Some Notes on the Ancient Egyptian Practice of Washing the Dead*, in *Journal of Egyptian Archaeology*, V (1918), pp. 118-20.

³ A. M. Blackman, *The House of the Morning*, in *Journal of Egyptian Archaeology*, V (1918), pp. 156-7, 159, 161-3. At the present time natron mixed with tobacco is chewed in Egypt.

⁴ British Museum, *Introductory Guide to the Egyptian Collections* (1930), p. 5; E. A. Wallis Budge, *The Literature of the Ancient Egyptians* (1914), pp. 14, 38, 218. Natron mixed with an odoriferous gum-resin, almost certainly incense, was found in the tomb of Tut-ankhamûn.

⁵ The remains of ancient glass factories still exist in the Wâdi Natrûn.

⁶ According to Pliny (XXXI, 46) the Egyptians used natron for cooking radishes, and at the present day it is used to a small extent in cooking vegetables.

⁷ J. H. Breasted, *The Edwin Smith Surgical Papyrus*, I, pp. 412, 491; C. P. Bryan, *The Papyrus Ebers* (1930), pp. 18-19, 22, 56, 60, 64, 88, 100, 104-5, 115, 130, 159-60, 165.

⁸ E. Bevan, *A History of Egypt under the Ptolemaic Dynasty* (1927), p. 148.

⁹ S. Lane-Poole, *A History of Egypt in the Middle Ages* (1901), p. 304.

(common salt) and sodium sulphate as impurities, these being present in very varying and often considerable proportions¹; thus, in 14 samples of natron from the Wâdi Natrûn analysed by the author,² the proportion of common salt varied from 2 to 27 per cent and that of sodium sulphate from a trace to 39 per cent, while in three samples from El-Kâb the common salt varied from 12 to 57 per cent and the sodium sulphate from 11 to 70 per cent. In three samples of natron from El-Kâb analysed by Lewin the common salt varied from 25 to 54 per cent and the sodium sulphate from 12 to 54 per cent.³

SALT

Common salt (sodium chloride) occurs abundantly in Egypt. At the present time it is procured commercially in large amount from Lake Mareotis in the north-west of the Delta and from salines at Port Said, but small quantities are also obtained surreptitiously from local deposits in various places. Pliny mentions⁴ a lake near Memphis from which salt, which he states was of a red colour, was extracted: he says⁴ too that one of the Ptolemies found salt near Pelusium (Damietta) and that it occurred beneath the sand in the desert between Egypt and Arabia and also in the western desert and that on the coast of Egypt there were artificial salines for the extraction of salt from sea water.

The flower of salt (*flos salis*) mentioned by Pliny⁴ that occurred in Egypt and was supposed to float down the Nile, but was also found on the surface of the water of certain springs, has not been identified, but it was certainly not patches of petroleum coming down from the White Nile, as suggested by Bailey,⁵ though there may be petroleum beneath Lake Albert and in the bed of the Kafu (a tributary of the Victoria Nile); and one has only to know the Nile in the Delta and to realize that it has travelled nearly 4,000 miles before it reaches the Delta, to be quite sure that no petroleum comes down floating on the

¹ For detailed analyses, see p. 430.

² A. Lucas, *Natural Soda Deposits in Egypt* (1912), pp. 15-16.

³ G. Schweinfurth, *op. cit.*, pp. 575-9.

⁴ xxxi, 39, 41, 42.

⁵ K. C. Bailey, *The Elder Pliny's Chapters on Chemical Subjects*, I, p. 168.

surface or that it ever did so come down. It seems probable that Pliny had been misinformed or that he made some mistake.

Herodotus says ¹ that in Egypt 'the ground is coated with salt (insomuch that the very pyramids are wasted thereby)' and he mentions ¹ 'salting factories' at Pelusium and the use of salt for mixing with oil for lamps.¹

Salt, in addition to its use as a seasoning for food, was largely employed in ancient Egypt for preserving fish. The question of its use in mummification will be dealt with in connexion with that subject.² Salt was a royal monopoly in the Ptolemaic period.³

SULPHUR

Sulphur occurs native in most volcanic districts and also, and usually in large quantities, associated with gypsum and it is in this latter connexion that it is found in Egypt: it occurs on Ras Jemsa (where it has been extensively worked in modern times); at Bir Ranga and at Ras Benas, all on the Red Sea coast.⁴ Small fragments of sulphur are also found occasionally in the limestone near Cairo ⁴ and it is deposited from the warm 'sulphur' springs at Helwan.

Sulphur has been found on at least two occasions in connexion with ancient Egypt, for example, several small pieces, weighing altogether about 6·5 grams, dating from late Badarian times were found by Brunton ⁵ and a small piece of late date (about the Twenty-sixth Dynasty) was discovered by Petrie at Defenneh.⁶ The Badarian specimens showed signs of having been melted. The most likely source of both of these is the Red Sea coast.

¹ II, 12, 15, 62.

² See p. 265.

³ E. Bevan, *A History of Egypt under the Ptolemaic Dynasty*, p. 149.

⁴ W. F. Hume, *Explan. Notes for the Geol. Map of Egypt*, pp. 40-1.

⁵ G. Brunton, *Qau and Badari III*, p. 34.

⁶ W. M. Flinders Petrie, *Nebesheh and Defenneh*, p. 75.

CHAPTER VIII

MUMMIFICATION

At what date mummification was first practised in Egypt is unknown, though there is evidence to show that it was probably as early as the Second Dynasty, since Quibell found at Saqqâra several tombs of this date in which the bodies had been elaborately bandaged, the limbs being wrapped separately.¹ From the beginning of the Fourth Dynasty there is the canopic box of Hetepheres (mother of Cheops, the builder of the great pyramid at Giza), which still contains packets of what presumably are the viscera preserved in a dilute (approximately 3 per cent solution) of natron, which is proof that the body had been embalmed, though it was not in the tomb (which contained a reburial, the original tomb probably having been robbed and the mummy destroyed) and, therefore, could not be examined.² From the Fifth Dynasty there is an Egyptian mummy in the Museum of the Royal College of Surgeons in London,³ from which period onwards mummification continued to be practised until early Christian times.

It is frequently assumed that the methods and materials employed in mummification are secrets that have not yet been discovered, which, however, is not so, and, except for a few minor details, there is little about the ancient process that is not well known, better known perhaps than at the time it was practised, since the methods were then purely empirical, whereas now the underlying principles are understood. So far as is known, the ancient Egyptian records do not contain any

¹ J. E. Quibell, *Excavations at Saqqara* (1912-1914), pp. 11, 19, 28, 32; Pl. XXIX (3).

² G. A. Reisner, *Bull. Mus. of Fine Arts, Boston*, xxvi (1928), No. 157.

³ G. Elliot Smith and W. R. Dawson, *Egyptian Mummies*, pp. 74-5.

mention of the methods of embalming and the earliest descriptions are those of Herodotus ¹ (who toured Egypt about the middle of the fifth century B.C.) and Diodorus ² (who visited the country about 400 years later), each of whom wrote an account of what he had seen and heard, including a description of the process of mummification.

According to Herodotus, three different methods of embalming were practised. In the first, which was the most expensive, the brain was removed, partly mechanically and partly by means of certain drugs (the nature of which is not given): the abdominal contents were removed (probably this was meant to include the thoracic contents also, except the heart and the kidneys, though this is not specifically stated) and the cavity, after having been cleaned with palm wine and spices, was filled with myrrh, cassia and other aromatic substances (the kinds of which are not specified) though frankincense was excluded, and the body, after the embalming incision had been sewn up, was then treated with natron, after which it was washed and wrapped in linen bandages, which were fastened together with gum. In the second method, 'cedar oil' was injected into the body, which was then treated with natron. The third method, which being the cheapest, was adopted by the poorer classes, consisted in cleaning out the intestines by means of a purge and afterwards treating the body with natron.

The account given by Diodorus, though possibly based on that of Herodotus, supplies several particulars not given by him though it is not so detailed. Although three grades of funerals are mentioned, only one method of embalming is given, namely, removal of the abdominal and thoracic viscera, except the heart and the kidneys: cleaning the viscera with palm wine mixed with various spices (the kinds of which are not specified): anointing the body with 'cedar oil' and other precious ointments (the kinds not being stated) and finally rubbing it with myrrh, cinnamon and similar materials in order to perfume and preserve it. In another connexion, when describing the bitumen of the Dead Sea, Diodorus states ³ that 'they transport this pitch into Egypt and there sell it for the use of the embalming of the dead; for if they do not mix

¹ II, 86-8.

² I, 7.

³ XIX, 6.

this with other aromatic spices, the bodies cannot be preserved long from putrefaction.'

As the two accounts are so much alike, one writer merely supplying details omitted by the other, they will be summarized and considered together, various errors and omissions being pointed out and the methods and materials explained and commented upon. It should not be forgotten, however, that these descriptions are of very late date and that during the interval between the first practice of mummification and the time they were written (about 3,000 years) the methods underwent considerable modifications and that, therefore, it is not to be expected that the descriptions should be accurate in every detail for the whole period.

1. In the most expensive method, though not in the less expensive ones, the brain and the abdominal and thoracic viscera (except the heart and kidneys) were removed. This agrees in the main with the facts found from an examination of a very large number of mummies, the heart always having been left in position and generally also the kidneys, but the brain and the rest of the viscera often having been removed.^{1, 2, 3} Sometimes, however, the mummies of those whose relatives would certainly have adopted the best and most expensive method of embalming in use at the time, have been found that have not been eviscerated, for example, that of queen Aashaït, wife of Mentuhotep II (Eleventh Dynasty) and that of Maït (possibly a princess) who was buried with the wives of Mentuhotep, both of whom were found by Winlock at El-Deir el-Bahari⁴ and examined by Derry.⁵ Pettigrew noticed a similar fact and states⁶ that 'Mummies very richly furnished and

¹ G. Elliot Smith, (a) *A Contribution to the Study of Mummification in Egypt*, in *Mém. de l'Inst. Égyptien*, v, fasc. I (1906); (b) *The Royal Mummies*, in *Cat. Gén. du Musée du Caire*.

² W. R. Dawson, *Making a Mummy*, in *Journal of Egyptian Archaeology*, XIII (1927), pp. 40-9.

³ G. Elliot Smith and W. R. Dawson, *Egyptian Mummies*.

⁴ H. E. Winlock, *Egyptian Expedition 1920-1921*, *Bull. Met. Mus. of Art*, New York, II, (1921), pp. 36-52.

⁵ D. E. Derry, *Report upon the Examination of Tut-ankh-Amen's Mummy*, in *The Tomb of Tut-ankh-Amen*, Howard Carter, II, p. 146.

⁶ T. J. Pettigrew, *History of Egyptian Mummies*, p. 60

prepared in the most costly manner have been found without the ventral incision.'

2. The abdominal and thoracic cavities and the viscera from them were cleaned with palm wine and spices, operations that naturally have not left any traces.

3. The body cavities were filled with myrrh, cassia and other aromatic substances and the embalming incision then sewn up. Herodotus specifically states that these operations took place before the natron treatment and, although Pettigrew,¹ Elliot Smith and Dawson^{2, 3} doubt this, it seems not unreasonable to think that an attempt may have been made to keep the body fragrant while it was undergoing treatment by putting in, temporarily or permanently, certain aromatic materials. The embalming incision, however, has rarely been found sewn up,⁴ and neither myrrh nor cassia has been identified with certainty from the abdominal or thoracic cavities. The principal packing materials found have been linen,⁵ linen and resin,⁶ sawdust,⁷ sawdust and resin,⁸ earth and natron,⁹ lichen¹⁰ and occasionally one or more onions.¹¹

4. The body was treated with natron. This is only mentioned by Herodotus and will be discussed later.

5. The body was washed. This also is only mentioned by Herodotus, but it seems a most natural and likely process and was probably always carried out. The author has suggested elsewhere¹² that the greater deterioration that is often seen in the bandages nearest the body, as compared with those on the

¹ T. J. Pettigrew, *op. cit.*, pp. 83-4.

² G. Elliot Smith and W. R. Dawson, *op. cit.*, p. 61.

³ W. R. Dawson, *op. cit.*, p. 43.

⁴ G. Elliot Smith and W. R. Dawson, *op. cit.*, pp. 61, 119.

⁵ Smith and Dawson, *op. cit.*, pp. 82, 83, 85, 103.

⁶ Smith and Dawson, *op. cit.*, pp. 75, 80, 97, 99, 103, 125.

⁷ Smith and Dawson, *op. cit.*, pp. 114, 115, 117, 118.

⁸ Smith and Dawson, *op. cit.*, p. 81.

⁹ Specimen analysed by the author taken from a body under examination by Dr. Derry and probably of about the Twenty-second Dynasty found by Winlock at El-Deir el-Bahari (H. E. Winlock, *op. cit.*, pp. 35-6).

¹⁰ G. Elliot Smith and W. R. Dawson, *op. cit.*, pp. 100, 103.

¹¹ G. Elliot Smith, *Mém. de l'Inst. Égyptien*, v, fasc. I (1906), p. 31.

¹² A. Lucas, *The Use of Natron in Mummification*, in *Journal of Egyptian Archaeology*, xviii (1932), pp. 139-40.

outside, may have been brought about in the first place by fungus, the growth of which was due to the body having been wrapped up while still damp, and, if so, this would prove that the body, in those instances at least, had been washed.

6. The body was anointed with 'cedar oil' and other precious ointments and then rubbed with myrrh, cinnamon and similar material. This is only mentioned by Diodorus, but in view of the great part played by the use of oil and ointments for the living,¹ some anointing of the dead seems very probable.

7. In the second method described by Herodotus 'cedar oil' was injected into the body and prevented from escaping until the end of the natron treatment.

8. In the third method described by Herodotus the nature of the purge employed for cleaning out the intestines is not stated, but almost any liquid, even plain water, if injected in sufficient quantity, would have been effective.

The materials mentioned by Herodotus and Diodorus as having been employed in the mummification process, as also certain materials stated by Pliny to have been used by the Egyptians for embalming and those found in recent times in connexion with mummies, taking them in alphabetical order, are: beeswax, bitumen, cassia, cedar oil, *cedri succus*, *cedrium*, cinnamon, gum, henna, juniper berries, natron, ointments, onions, palm wine, resins (including gum-resins and balsams), salt, sawdust, spices and wood tar or wood pitch, all of which may now be considered.

BEESWAX

Beeswax, which will be dealt with more fully in connexion with oils and fats, was often employed in mummification for covering the ears, eyes, nose, mouth and embalming incision^{2, 3} and eleven specimens of such material have been examined by the author, the results of eight of which have been published⁴: beeswax was also employed on other parts of the body, thus in the case of a female mummy (No. 23) of the Eleventh Dynasty

¹ See p. 85.

² G. Elliot Smith, *op. cit.*, p. 28.

³ G. Elliot Smith and W. R. Dawson, *op. cit.*, pp. 113, 117, 124.

⁴ A. Lucas, *Preservative Materials used by the Ancient Egyptians in Embalming*, p. 53.

found by Winlock at El-Deir el-Bahari, which Dr. Derry kindly allowed the author to examine, there was a brown incrustation, about one to two millimetres thick, on the thighs and on the back, which on analysis proved to be beeswax.

BITUMEN

From a study of the literature of mummification there would seem at first thought to be no doubt whatever that natural bitumen (pitch) from the Dead Sea was extensively employed in Egypt in the preservation of the dead, thus both Diodorus¹ and Strabo,² when referring to the Dead Sea, state that the bitumen from it was used by the Egyptians for embalming, though the former makes no mention of it in his detailed description of the embalming process³ and all modern writers on mummification until recently also state that bitumen was used, but the author queried this some years ago,⁴ and his views on the subject (namely, that bitumen was certainly never employed for mummification until Ptolemaic times at the earliest, when possibly it may have been used) seem now generally to be accepted, thus Ruffer, writing after he was aware of the author's opinion, says,⁵ 'It is a peculiar fact that I have never yet found bitumen in any mummy, and my experience now extends from Prehistoric to Coptic times'; and Dawson writes⁶ '... bitumen, although described in modern books as the staple embalming material, was never used until Graeco-Roman times, and, if then, by no means universally.'

¹ XIX, 6.

² XVI, II, 45.

³ Herodotus, however, although he refers to bitumen on several occasions, and describes the methods and materials used by the Egyptians in embalming, does not mention bitumen as having been employed. Pliny, too, also frequently refers to bitumen, but says nothing about its use in mummification, though he mentions other materials that were so used, and Josephus and Tacitus both describe the Dead Sea and the occurrence of bitumen, but do not refer to any use of it for embalming.

⁴ A. Lucas, (a) *Arch. Survey of Nubia, Report for 1907-1908*, II (1910), pp. 372-4; (b) *Preservative Materials used by the Ancient Egyptians in Embalming* (1911); (c) *Journal of Egyptian Archaeology*, I (1914), pp. 241-5; (d) *Ancient Egyptian Materials* (1926), pp. 122-4.

⁵ M. A. Ruffer, *Histological Studies on Egyptian Mummies*, in *Mém. de l'Inst. Égyptien*, VI, fasc. III (1911), p. 6, footnote dated March 1911.

⁶ W. R. Dawson, *op. cit.* (1927), p. 46.

The mistake has been due to the facts that much of the material, especially from the later mummies, is black and looks very like bitumen and that no systematic examination by modern chemical methods was made. The only results that can be traced where such methods have been employed are by Reutter, by Spielmann and by the author.

Reutter analysed six specimens of Egyptian mummy material in all of which he states that bitumen was present.¹ Three of these specimens were from human mummies (one of the Thirtieth Dynasty and two undated); one was from a bird mummy (ibis) also undated; one consisted of a bundle of bandages from bird mummies (undated) and one was from a canopic box (undated). The first of these is very late and falls within the period when bitumen might have been used and the rest may also be late and within the same period. Also, if bitumen were used, it seems much more likely to have been for non-human mummies, such as those of birds, than for human mummies, since it was probably a cheaper material than resin. The specimen from the canopic box may not have been the material used for preserving the viscera, but an anointing substance poured over them after they had been put into the box, as was sometimes done² and, though the finding of bitumen in it would be of interest, its classification as an embalming material may be incorrect. The tests relied upon by Reutter for the identification of bitumen were (a) that a blackish coloured residue that he separated from the material (in one instance by means of carbon disulphide) contained sulphur; (b) that in one instance this residue reduced sulphuric acid to sulphurous acid when heated and (c) that in one instance the residue had a bituminous smell. It is true that bitumen contains sulphur, but so do other materials: the production of sulphurous acid when the blackish residue was heated with sulphuric acid is in no way a test for bitumen, as the same reaction occurs when

¹ L. Reutter, (a) *De l'embaumement avant et après Jésus-Christ* (1912), pp. 45, 50, 56, 66, 67; (b) *De la Momie ou Mumia*, in *Bull. des Sciences Pharmacologiques*, Paris (no date), pp. 49-58; (c) *Analyse d'une masse résineuse égyptienne ayant servi à l'embaumement d'animaux sacrés conservés au Musée de Neuchâtel*, in *Sphinx*, xvii (1913), pp. 110-14.

² See p. 252.

carbon or almost any carbonaceous matter is treated in this manner. To test for sulphur after having dissolved the material in carbon disulphide and evaporated off the solvent is unwise, as carbon disulphide often contains free sulphur, and to depend upon the smell for the recognition of bitumen is most unsatisfactory. By means of these same tests Reutter has also identified bitumen in ancient Egyptian perfumes,¹ though it seems a most unlikely material to have been used for such a purpose.

Spielmann² relied upon the most modern methods for the detection of bitumen, namely, the behaviour of the specimens when exposed to ultra-violet rays and the spectroscopic analysis of the ash. The first of these methods had previously been tried by the author with various resinous materials (two pre-dynastic, three early dynastic, one Twentieth Dynasty and three of amber) with a view, if possible, to differentiate between them and so to separate them into groups according to their botanical origin; but unfortunately it has not yet been possible to continue the work, although the results were interesting and in some instances promising.

The specimens examined by Spielmann were all supplied by the author and were as follows: namely, three of modern bitumen of Judea; one of modern wood pitch; one of probable wood pitch from a mummy (undated); four resins, manifestly without any admixture of bitumen; three from ancient graves and one from an ancient jar, but only one of them from a mummy (Ptolemaic) and five pitch-like materials all from mummies (one Twentieth Dynasty; one Twenty-first Dynasty and three Ptolemaic), all of which are late, three falling within the very late period when bitumen may have been used.

Spielmann states that the appearance of the specimens when exposed to the ultra-violet rays show that the black mummy materials 'occupy positions between the undoubted bitumens and the undoubted resins.' Although this is true, it has not necessarily any significance with respect to the presence or absence of bitumen, and Spielmann only suggests that it raises

¹ See p. 89.

² P. E. Spielmann, *To what extent did the Ancient Egyptians employ Bitumen for Embalming*, in *Journal of Egyptian Archaeology*, XVIII (1932), pp. 177-80.

'the expectation that the presence of bitumen would become substantiated by further work rather than disproved.'

The results of the spectographic analysis showed that the elements characteristic of bitumen were vanadium, nickel and molybdenum: the resins were free or almost free from these three elements and the black mummy materials contained vanadium varying from a very slight trace to a heavy trace and nickel and molybdenum from none to a heavy trace. A specimen of north European wood pitch did not contain any of the three elements in question.

If Dead Sea bitumen always contains vanadium, nickel and molybdenum (which is highly probable), then it follows that any mummy material without all three of these tell-tale elements cannot contain bitumen and, therefore, two of the specimens at least (one Twenty-first Dynasty and one Ptolemaic) are free from bitumen. With respect to the other three specimens, which contain all three of the tell-tale elements, Spielmann thinks there is 'strong evidence' for the presence of bitumen, and he suggests that the materials consist of wood pitch containing bitumen in 'a relatively low proportion . . . because the characteristic metals are not very pronounced' and also containing resin in 'a relatively low proportion . . . because the ochre fluorescence is not strong.' But it seems unreasonable to have added bitumen to wood pitch and likely, if bitumen had been employed, that it would either have been alone or in large proportion in any mixture. Also the results of the author's analyses of these same specimens¹ have not been taken into account. Thus, all the five black mummy materials were free from anything soluble in petroleum spirit, except fatty matter, derived from the bodies with which they had been in contact, whereas the specimens of genuine bitumen contained from 38.80 to 53.70 per cent of soluble matter. Again, three of the black mummy materials contained only 0.92, 1.45 and 1.93 per cent of sulphur respectively,² whereas two of the genuine bitumens contained 8.58 and 8.85 per cent respectively of sulphur,² and in the black mummy materials there was an

¹ A. Lucas, *Preservative Materials used by the Ancient Egyptians in Embalming*, pp. 39, 43.

² The other specimens were not examined for sulphur.

absence of any smell suggestive of bitumen and an absence also of the fluorescence when the materials were dissolved in various solvents that is so characteristic of bitumen, and the colour and smell of the matter extracted by solvents were not those of bitumen. Possibly, however, if a considerable number of specimens of material of late date were examined definite proof of bitumen might be found, the author, as stated some years ago, regarding 'as likely the occasional use of bitumen about the Ptolemaic period.'¹

In the Demotic text of one of the Rhind papyri (Ptolemaic period) the name of one of the materials mentioned as being employed for filling the cranial cavity is translated by Möller as *syrischem Asphalt*² (Syrian asphalt) and Brugsch had previously translated it as *syrischem Salze*³ (Syrian salt), but both of these are guesses, the exact meaning of the demotic word used being unknown, and in the author's opinion it is more likely to mean resin, a much more important Syrian product to the Egyptians than either asphalt or salt, and one known and used in Egypt from a very early date, and Dr. J. Černý informs the author that the same word is employed to describe a certain material used for covering or coating coffins, which may have been either the varnish so common on coffins of a late date (Twentieth to about the Twenty-sixth Dynasties),⁴ which consists of resin, possibly obtained from Syria or through Syria, or the black anointing material to be described later.⁵

CASSIA AND CINNAMON

Cassia and cinnamon will be considered together for reasons that will be apparent.

One difficulty encountered when dealing with ancient materials is that not infrequently the same name has been applied to different substances at different periods, cassia and cinnamon being cases in point, the cassia of the ancients sometimes having been the modern cinnamon.

¹ A. Lucas, *Ancient Egyptian Materials*, p. 123.

² G. Möller, *Die beiden Totenpapyrus Rhind des Museums zu Edinburg*, I, p. 3, l. 8.

³ H. Brugsch, *A Henry Rhind's Zwei Bilingue Papyri*, I, p. 3, l. 4.

⁴ See p. 300.

⁵ See p. 252.

Cassia and cinnamon are very similar to one another, both being the dried bark of certain varieties of laurel that grow in India, Ceylon and China (cassia being from *Cinnamomum cassia* and cinnamon from *Cinnamomum zeylanicum*), cassia, however, being more pungent, more astringent, less delicate in flavour and thicker than cinnamon. Anciently both cassia and cinnamon consisted, not only of the bark, but included also flower-tops, twigs and wood.

The earliest references to cassia that can be traced in the ancient Egyptian records are in the Papyrus Harris of the Twentieth Dynasty, where both cassia and cassia wood are mentioned,¹ and the earliest references to cinnamon are in the Eighteenth² and Nineteenth³ Dynasties respectively, where it is stated that it was obtained from Punt and, though cinnamon is not a product of Punt, it might well have reached Egypt through that country. Cinnamon and cinnamon wood are also frequently mentioned in the Papyrus Harris.⁴

Both cassia and cinnamon were well known to the Greeks and Romans and are described by Herodotus,⁵ Theophrastus,⁶ Pliny⁷ and other writers, Pliny stating that cinnamon 'grows in the country of the Ethiopians,' which, however, is not so.

In the ancient Egyptian records the use made of cassia and cinnamon is not specified, but they would naturally have been employed as flavouring and perfuming materials and also possibly as incense, and as already shown Herodotus mentions cassia and Diodorus mentions cinnamon (possibly the same material being meant in both cases) as having been used in mummification.

Two references to the finding of cassia or cinnamon in connexion with mummies can be traced, one by Osburn, who says of a mummy (probably of the Twentieth Dynasty) that 'a thick layer of spicery covering every part of it . . . this external covering, which is nowhere less than an inch in thickness and which is interposed everywhere between the bandages and the skin . . . still retains the faint smell of cinnamon or cassia . . . but when mixed with alcohol or water and exposed to the action of heat the odour of myrrh becomes very powerfully pre-

¹ J. H. Breasted, *op. cit.*, IV, 234, 344, 379. ² II, 265. ³ III, 116.

⁴ IV, 234, 240, 287, 300, 344, 348, 378, 391, 394.

⁵ III, 107-11.

⁶ IX, 5, 1-3.

⁷ XII, 41-3.

dominant.’¹ This is quoted by Pettigrew,² who also says of a mummy he had examined, ‘I have seen the cavity merely filled with the dust of cedar, cassia, etc. and an earthy matter.’³ Neither of these identifications can be considered satisfactory or final.

CEDAR OIL, *CEDRI SUCCUS*, *CEDRIUM*

These three materials have been dealt with by the author elsewhere,⁴ and it has been shown that the substance referred to by both Herodotus and Diodorus and translated ‘oil of cedar’ was probably not a cedar product, but a juniper product, and, as the writers are at variance with respect to the method of its application (one stating that it was injected and the other that it was employed for anointing), either two different substances were meant or one or other was mistaken. Since there is no certainty about the manner in which the ‘oil of cedar’ was used (each method requiring a different material) it is impossible to be sure of its nature. If injected, it was probably either impure oil of turpentine or pyroligneous acid containing admixed oil of turpentine and wood tar, and if employed for anointing, it was probably volatile oil of juniper dissolved in whatever fixed oil was used to extract it, but no Egyptian evidence has been found for the use of any of these materials. In neither case, however, could it have been a fixed oil of any coniferous tree, since no such oil was then known.⁵ The use of ‘cedar’ oil in connexion with burial was continued certainly as late as the end of the first century A.D.⁶

The *cedri succus* (cedar juice) of Pliny⁷ was the natural resinous exudation of some coniferous tree, probably never the cedar, but often the juniper, and for the extensive use of some such material by the Egyptians in embalming there is ample evidence.

¹ W. Osburn, *An Account of an Egyptian Mummy presented to the Museum of the Leeds Philosophical and Literary Society* (1828), p. 6.

² T. J. Pettigrew, *op. cit.*, p. 60. ³ T. J. Pettigrew, *op. cit.*, pp. 62-3.

⁴ A. Lucas, ‘Cedar’-Tree Products employed in Mummification, in *Journal of Egyptian Archaeology*, xvii (1931), pp. 13-21.

⁵ See p. 275.

⁶ B. P. Grenfell and A. S. Hunt, *The Amberst Papyri*, II, p. 150.

⁷ xxiv, 11.

Cedrium, as defined by Pliny,¹ was pyroligneous acid containing admixed oil of turpentine and wood tar, for the use of which no Egyptian evidence has been found. The term *cedrium*, however, might not unreasonably have been used to mean wood tar alone, which was sometimes employed by the Egyptians for embalming.

GUM

According to Herodotus,² gum was employed to fasten together the linen bandages in which the mummy was wrapped after embalming, with reference to which he states ² that 'the Egyptians mostly use it instead of glue.' Gum has been identified on mummy bandages in two instances (undated) by Reutter³ and in four cases (all Twentieth Dynasty) by the author and in the case of the mummy of Amenophis III 'a sheet of cloth saturated with some gum-like material was placed in front of the face.'⁴ But, although gum was sometimes used, this may not always have been so, for example if molten resin were poured over the body, as apparently was sometimes done, since mummy bandages are often stiff with it, no other adhesive would have been required. Gum is largely obtained at the present day from various species of acacia that grow in the Sudan, but as the acacia also grows in Egypt and was probably more plentiful formerly than it is now, the greater part, if not the whole, of the ancient supply may have been local. Pliny states ⁵ that in his day the best gum was obtained from Egypt.

HENNA

Henna has already been mentioned in connexion with cosmetics and perfumes,⁶ where it was suggested that the flowers, which are odoriferous, were probably employed in ancient Egypt

¹ XVI, 21.

² II, 86.

³ L. Reutter, (a) *De l'embaumement avant et après Jésus-Christ*, pp. 52, 60 ; (b) in *Sphinx*, XVII (1913), p. 113.

⁴ G. Elliot Smith, *The Royal Mummies*, in *Cat. Gén. du Musée du Caire*, p. 48.

⁵ XIII, 20 ; XXIV, 67.

⁶ See p. 87.

for perfuming unguents and also that the leaves were used as a cosmetic to colour the palms of the hands, the soles of the feet and the hair, as is done to-day.

The henna plant (*Lawsonia inermis*) is a perennial shrub that grows abundantly in Egypt; it is cultivated in gardens for its strong smelling flowers and as a farm crop for its leaves, the chief use of which is as an article of toilet, a paste being prepared from them with which the hands, feet, nails and hair are coloured red: a decoction of the leaves is stated to be occasionally used for dyeing cloth.

That the finger and toe nails of mummies are sometimes stained has often been noticed. Thus Rouyer says¹ that certain mummies had the palms of the hands, the soles of the feet and the nails of the fingers and toes stained red with henna. This is quoted by Pettigrew, who says² that 'Mr. Davidson's mummy presented this stained appearance on the nails. Mr. Madden also says that the hands of many were dyed with the juice of the henna.' Naville states³ that the finger nails of an Eleventh Dynasty mummy were tinted with henna and Maspero thought that the hands of Ramesses II were stained 'jaune-clair par les parfums.'⁴ Elliot Smith suggests, however, that the discoloration had been caused by the embalming material, which may have also been the case with the mummy to which Naville refers, as it almost certainly was with the staining of the nails of a number of mummies examined by the author. Pettigrew well sums up the matter as follows²: 'The nails of the fingers and toes of some mummies have been observed to be stained, as if with henna . . . Whether this be really the case is not at all clear; the colour may probably be produced by the medicaments employed in the process of embalming.' Elliot Smith describes the hair of the mummy of Henttawi (Eighteenth Dynasty) as being dyed a brilliant reddish colour, which he suggests had been done with henna.⁵

¹ P. C. Rouyer, *Notice sur les embaumemens des anciens Égyptiens*, in *Description d'Égypte, Antiquités, Mémoires*, I (1809), pp. 207-20.

² T. J. Pettigrew, *op. cit.*, p. 66.

³ E. Naville, *The Eleventh Dynasty Temple at Deir-el-Bahari*, I (1907), p. 44.

⁴ G. Elliot Smith, *The Royal Mummies*, pp. 60-1.

⁵ G. Elliot Smith, *op. cit.*, p. 19.

JUNIPER BERRIES

Juniper berries, generally those of *Juniperus phænicea*, have frequently been found in ancient Egyptian graves, the earliest that can be traced being from two different tombs of the Eighteenth Dynasty¹; Kunth found them among the Passalacqua collection²; Loret mentions specimens from two tombs at Thebes³; Newberry identified 'a quantity of twigs . . . to which in a few cases the berries were still attached' from crocodile mummies of Ptolemaic date found by Petrie at Hawara⁴; in the description of the Christian bodies found in Nubia, Elliot Smith and Wood Jones mention 'little round berries,'⁵ which the author, who saw many of them at the time, believes to have been juniper berries, and in a report dealing with some of this material he states⁶ that 'In Nubia, in a cemetery thought to be about . . . the fifth century A.D., the bodies . . . were packed in large quantities of salt, mixed in some instances with the same kind of small globular fruit or berries already mentioned.' This reference is to another specimen of preservative material, submitted by Elliot Smith, from a Coptic 'mummy' of the fifth century A.D. from Naga el-Deir, which 'consisted of a mixture of common salt and small globular fruit or berries about the size of a pea.'⁶

Writing of the Coptic monastery of Epiphanius at Thebes, Winlock says⁷: 'The body was then laid on the first grave sheet and handfuls of coarse rock salt and juniper berries were placed between the legs and over the trunk inside and outside the innermost wrappings,' and again 'berries of *Juniperus*

¹ E. Schiaparelli, *Relazione sui Lavori della Missione Archeologica Italiana in Egitto* (1903-20), II, p. 165. The other instance was from the tomb of Tutankhamûn, which has not yet been published.

² C. Kunth, in *Cat. des antiquités découvertes en Égypte*, J. Passalacqua, p. 228.

³ V. Loret, *La Flore Pharaonique*, 2nd ed., p. 41.

⁴ P. E. Newberry, in *Hawara, Biahmu and Arsinoe*, p. 52.

⁵ G. Elliot Smith and F. Wood Jones, *Report on the Human Remains*, in *Arch. Survey of Nubia, Report for 1907-1908*, p. 218.

⁶ A. Lucas, *Preservative Materials used by the Ancient Egyptians in Embalming*, p. 20.

⁷ H. E. Winlock and W. E. Crum, *The Monastery of Epiphanius at Thebes*, pp. 48, 61.

phænicea were common enough to be used in large quantities as an embalming agent in the graves.'

In the Cairo Museum there are both juniper seeds and berries of Twentieth Dynasty date from the 'cache' at El-Deir el-Bahari where the royal mummies were found and also berries of the Twenty-sixth Dynasty from El-Qurna.

It seems manifest that when juniper berries were placed on the body this must have been done either on account of some fancied preservative effect or because they had a ritual significance. But the former reason would not have led to the putting of the berries in baskets or other receptacles in the tomb as was sometimes done and, therefore, they probably always had some symbolical meaning. To the author, these berries seem to be directly connected with the 'cedar' wood used for coffins and shrines and the 'cedar' oil employed for anointing the dead body, which played such important parts in the burial of royal and other prominent personages, since, as has been pointed out elsewhere,¹ the 'cedar' oil was probably not from the cedar, but often essential oil of juniper extracted from the berries by soaking them in some ordinary fixed oil, and juniper and other coniferous woods were sometimes substituted for cedar.

Although the juniper is distributed throughout the whole of the rest of the Mediterranean region, it does not grow in Egypt, but because the berries have been found so frequently in Egyptian tombs, it has been assumed that the tree must have flourished formerly in the country, for which there is no evidence, and the same line of reasoning would prove that it must have been common in Upper Egypt in early Christian times (since it was in Upper Egypt and at a very late period that the berries seem principally to have been used), though this is most unlikely and it is much more probable that the berries, like the oil and the wood, should have been imported from western Asia.

NATRON

The occurrence of natron in ancient Egypt and its use, except for mummification, has been dealt with in connexion with

¹ A. Lucas, 'Cedar'-Tree Products employed in Mummification, in *Journal of Egyptian Archaeology*, xvii (1931), pp. 14, 15, 21.

minerals¹ and there remains, therefore, only its employment in embalming to be considered, which has been described by the author elsewhere,² but which may here briefly be summarized.

Natron in the solid state has been found (a) in vases and jars in tombs ; (b) frequently buried with refuse embalming material, an instance additional to the many mentioned being the 'packages of white powder' (which was almost certainly natron), found by Wainwright in a grave of Twenty-fifth Dynasty date³ ; (c) encrusting a wooden embalming platform and its accessories of the Eleventh Dynasty ; (d) on and in mummies, examples of which have been given in the article referred to, but three other instances of which may be mentioned, namely (1) in a body of about Twenty-sixth Dynasty date found by Winlock at El-Deir el-Bahari,⁴ from which Dr. Derry, who had it under examination, allowed the author to take a portion of the packing material from the thorax for analysis, which proved to be a mixture of natron, earth and linen ; (2) in a body of Middle Kingdom date from Saqqâra, where 'In the cavity of the chest were nodules of natron, about 10 of them . . .'⁵ and (3) in a Twenty-fifth Dynasty mummy, where a small linen packet containing white powder (almost certainly natron) was found stuffed in the mouth.⁶

Natron has also been found on two occasions in tombs in the form of a solution in a canopic box.⁷

Of the employment of natron, therefore, in embalming there cannot be any doubt and its use extended from at least as early as the Fourth Dynasty to at least as late as the Persian period. Pliny possibly refers to the use of natron by the Egyptians in mummification.⁸ The embalmer's workshop was 'The Place

¹ See p. 221.

² A. Lucas, *The Use of Natron in Embalming*, in *Journal of Egyptian Archaeology*, xviii (1932), pp. 125-40.

³ G. A. Wainwright, in *Heliopolis, Kafr Ammar and Shurafa*, W. M. Flinders Petrie and others, p. 35 ; Pl. XXIX.

⁴ H. E. Winlock, *Egyptian Expedition for 1920-1921*, in *Bull. Met. Mus. of Art*, New York, 1921, II, 35-6.

⁵ J. E. Quibell and A. G. K. Hayter, *Excavations at Saqqara, Teti Pyramid, North Side*, p. 12.

⁶ G. A. Wainwright, *op. cit.*, p. 35.

⁷ A. Lucas, *op. cit.*

⁸ K. C. Bailey, *The Elder Pliny's Chapters on Chemical Subjects*, I, pp. 53, 172-3.

of Purification' and it was there that the dead were treated with natron, which was considered by the ancient Egyptians to be the great purifying agent. It is always stated that the natron was employed in solution, that is as a bath in which the body was soaked, but the author believes that this was not so and that solid natron was used (except occasionally for the viscera), the body being buried in the dry material, as described by Herodotus,¹ and, since natron is a dehydrating (desiccating) agent, the body would dry up without the production of more than very slight decomposition or disagreeable smell. The idea of a bath is largely based upon a mistranslation of Herodotus, and the proofs that the natron was used dry and not as a solution have been given fully in the article² to which reference has been made and, therefore, need not be recapitulated.

To this new and somewhat revolutionary proposition of the use of dry natron, only two objections have been received, one from Mr. Warren Dawson and one from Mr. Battiscombe Gunn.

Mr. Warren Dawson says³: 'I have examined a great number of mummies, and, with the exception of two cases, the epidermis was always entirely absent from the whole body, except from the head, fingers and toes where its cut edges are visible. I agree that simple maceration might not be sufficient to detach the whole of the cuticle, but it would certainly loosen it and make it easy to remove by scraping, a practice followed in other parts of the world. I have also both seen and read of packets of detached epidermis wrapped in linen and buried with the mummy. With the exception of the two cases afore mentioned, I have never found a trace of pubic, axillary or other body-hair, nor even stumps that might indicate cutting or shaving. It always comes away with the epidermis.'

That the epidermis, except for that on the head, fingers and toes, is often missing; that packets of shed epidermis have occasionally been found with mummies⁴ and that body hair is

¹ II, 86.

² A. Lucas, *The Use of Natron in Mummification*, in *Journal of Egyptian Archaeology*, XVIII (1932), pp. 125-40.

³ Private letter dated 14th May, 1933.

⁴ G. Elliot Smith and F. Wood Jones, *Report on the Human Remains*, in *Arch. Survey of Nubia, Report for 1907-1908*, pp. 200-1.

generally absent are not disputed. This question of the missing epidermis was raised and answered in the original article, and Sir Armand Ruffer, a pathologist, who had made a special study of Egyptian mummies, was quoted¹ on the matter as follows: that at first he 'attributed this state of things to the effect of the salt bath, but that it cannot be wholly due to this is proved by the fact that the epidermis of bodies which had certainly never been placed in the bath had also fallen off.' He states, too, that 'in many cases the epidermis, especially that of the toes and hands, is practically normal'; 'it has been taken for granted that the natron bath . . . would so soften the skin that the epidermis would either fall off in the bath or be easily stripped off afterwards, and because the epidermis has evidently been removed in some instances, this was assumed to have been the result of the natron bath'; 'very often . . . the epidermic layer is absent, but in mummies of the Twenty-first Dynasty . . . the epidermic layer can often be demonstrated'; 'the skin of mummies of the Roman epoch is as a rule perfect, the epidermis shows no signs of having been shed'; 'it has been taken for granted that a solution of natron . . . would loosen the cuticle so much that this could easily be removed. As a matter of fact the evidence . . . is nil'; 'the fact that the skin, including the epidermis, of certain bodies was almost normal shows that the "natron" bath cannot always have had a very powerful macerating effect.' Ruffer further explains that 'with the onset of putrefaction the epidermis is raised and ultimately falls off,' and quotes the instance of the body of a child where 'there was absolutely no sign that it had been touched by the embalmer,' and yet 'the whole of the epidermis of the soles of the feet and toes was almost completely detached.' The fact that the epidermis of mummies is often absent, therefore, is not proof that the body had been soaked in a solution, since putrefaction alone may have been the responsible agent.

Elliot Smith says of one mummy he examined that 'Unlike all other mummies examined by me (excepting only those of the Coptic period) the epidermis was not removed during the process of embalming. It is still present, peeled off, it is true, but

¹ A. Lucas, *op. cit.*, p. 139.

adhering to the bandages wherever they came in contact with the body.'¹ May it not be that in other instances, for example, where the mummy or bandages were in a poor condition (the bandages next to the body sometimes being blackened and friable or even in a powdery condition)² that the epidermis was present, adhering to the bandages, but was not recognized?

Mr. Battiscombe Gunn writes³: 'One point, however, strikes me in this connection. The well-attested fact that mummies when unwrapped are often found either to have a limb or limbs missing, and replaced with sticks, etc., or else to be made up with other people's limbs, having three arms and one leg, or vice versa—this fact is usually explained by the body having come apart in the pickling bath. If the bodies were merely dehydrated with dry natron, it is not so easy to explain the loss of limbs. Have you any alternative explanation?' 'I think that with many people such cases will constitute a strong objection to your theory.'

The facts mentioned are well known. Jomard in 1809 refers to ancient false mummies⁴ and examples have been found in Nubia⁵ and elsewhere. These defective and composite mummies are of two main classes, namely, (a) those like the royal mummies found at El-Deir el-Bahari and in the tomb of Amenophis II at Bibân el-Mulûk respectively, which had been maltreated by robbers in search of plunder and subsequently restored and re-wrapped and then hidden to protect them from further damage, the condition of which has no connexion with the method of embalming and (b) mummies not damaged by robbers and re-wrapped. Some of these latter are deliberate frauds made in modern times and often put into genuine old coffins in order to sell to tourists. Jomard in 1809 says⁴ that not only were there

¹ G. Elliot Smith, *The Royal Mummies*, in *Cat. Gén. du Musée du Caire*, p. 9.

² Elliot Smith (*op. cit.*, p. 116) states that in one case of a mummy examined by him 'The flesh and innermost wrappings were entirely corroded . . . so that the bones of the skeleton were found lying amidst a large quantity of black powder.'

³ Private letters dated Feb. 2nd, 1933, and May 11th, 1933.

⁴ E. Jomard, *Description des Hypogées de la Ville de Thèbes*, in *Description d'Égypte*, 1809, I, pp. 345-6.

⁵ G. Elliot Smith and F. Wood Jones, *The Human Remains*, in *Arch. Survey of Nubia, Report for 1907-1908*, pp. 213-15.

ancient false mummies, but that in his day the Arabs and the Jews made modern ones, and Pettigrew in 1834 states¹ that Mr. Madden saw 'a manufacture of mummies' at El-Qurna, opposite Luxor (where false antiquities are still made), these being put into old coffins. Other defective mummies may be incomplete because the body had been allowed to undergo considerable decomposition before it was embalmed, as for instance, according to Herodotus, was customary in the case of women of the better class.² With reference to this, Elliot Smith and Warren Dawson state³ that 'It may be observed that there is abundant evidence that some of the bodies were in an advanced stage of decomposition when treated by the embalmers, and this condition in nearly every case applied to women.'

But, allowing for both the categories mentioned, there still remains a large number of mummies, the state of which requires accounting for. The usual explanation, either given or implied, is that their condition is due to the bodies having been soaked in an embalming solution in such a manner or for such a period that they became dismembered and that insufficient care was taken to keep the several parts of one body separate from those of other bodies, in consequence of which mistakes were made in assembling the parts, whereby some bodies had limbs missing or limbs allotted to them that did not belong. But no evidence is offered to show that soaking in a natron solution, even if prolonged, would cause the limbs to separate from the body, but that this might happen with certain strengths of natron is not denied, though it did not happen in some experiments made by the author with chickens and pigeons that were soaked in natron solutions,⁴ but it did occur in one instance when a solution of common salt was used in place of natron.⁴ But, even though it be accepted that the use of a natron bath had caused dismemberment of the bodies, for which, however, there is not proof, this would solve only part of the problem. The defective and composite mummies that are not cases of re-wrapping are practically, if not entirely, limited to very late periods, Persian, Ptolemaic and Roman, and apparently most,

¹ T. J. Pettigrew, *A History of Egyptian Mummies*, p. 228. ² II, 89.

³ G. Elliot Smith and Warren H. Dawson, *Egyptian Mummies*, p. 125.

⁴ A. Lucas, in *Journal of Egyptian Archaeology*, XVIII (1932), pp. 133-4.

if not all, are of persons of the poorer classes and, therefore, any explanation, before it can be accepted, must show the reason for this limitation in both time and status, which the bath theory does not.

The condition of these late mummies is probably correlated to the fact that about the beginning of the period to which they belong 'less and less attention was paid to the body and more and more to the external wrappings'¹ and 'the processes were getting slipshod and the practitioners careless, when much of the care which in earlier times was devoted to the body itself was now being given mainly to the outward appearance of the wrapped mummy,'² and so long as this 'displayed a presentable exterior it seemed to matter little to the embalmer how careless and slipshod was the work upon the corpse concealed beneath the carefully wrought external coverings.'¹

No wholly satisfactory solution of the difficulty can be suggested, but two facts are certain, namely, first, that the bodies must have been desiccated in some manner before they were wrapped up (which, as shown elsewhere,³ was best attained by the use of dry natron) and second, that more than one body was dealt with at the same time and place, hence some 'wholesale' treatment seems indicated. Whatever it was there must have been some deviation from the old practice, since it is only at the late periods that the defective and composite mummies are found. Some method resulting in a considerable decomposition of the body seems certain, possibly a method dictated by the need of economy (since more expense was being incurred for the wrapping). One obvious economy would have been to reduce the amount of natron used (that the great purifying agent should have been entirely omitted is unlikely) and another might have taken the form of the repeated use and re-use of the same natron until it had little or no preservative property left.

OINTMENTS

The nature of the 'precious ointments' mentioned by Diodorus as having been employed for anointing the body after

¹ G. Elliot Smith and Warren R. Dawson, *op. cit.*, p. 121.

² G. Elliot Smith and F. Wood Jones, *The Human Remains*, in *Arch. Survey of Nubia, Report for 1907-1908*, pp. 213-15.

³ A. Lucas, in *Journal of Egyptian Archaeology*, XVIII (1932), pp. 133-4.

mummification, is not stated and there is no evidence from the mummies whereby the composition can be ascertained. Several late (Ptolemaic and Roman) papyri ^{1, 2, 3} give a description of the religious ceremony that took place after the body had been prepared by the embalmers, but before it had been wrapped and also during the wrapping, the former of which consisted in anointing the body with certain unguents composed of odoriferous gum-resins (frankincense and myrrh) and various oils and fats (including 'cedar' oil, boiled fat, ox fat and ointments) and another late papyrus (first century A.D.) ⁴ mentions among the funeral expenses the purchase of 'cedar' oil and olive oil.

But after the mummy had been prepared, anointed and wrapped there was apparently sometimes another ceremony which consisted in pouring a liquid or semi-liquid resinous material over the mummy and sometimes also over the coffin and over the viscera after they had been put into the canopic box. This also may not unreasonably be considered an anointing. This latter treatment has been recorded in a number of instances, thus Petrie describing two Fifth Dynasty burials at Deshasheh, says ⁵ of one ' . . . coffin contained a woman fastened in place by some pitch poured over the body ' and of another, ' The body wrapped up lay fixed by some pitch.' Mace and Winlock state ⁶ with regard to the Twelfth Dynasty mummy of Senebtisi that ' Immediately inside the coffin and overlying the mummy there was a layer of some resinous material. . . . It is clear . . . that it was poured in semi-liquid state over the mummy. . . . The purpose of this resin treatment is not easy to explain, but from the evidence of the Dashur burials and of other graves in the same cemetery at Lisht it was not an uncommon practice of the period.' They also say, ' From coffins now in the Metropolitan Museum it is clear that a similar treatment was in use at Meir, as resin was poured over the anthropoid coffin of Hapi

¹ A. Mariette, *Les papyrus égyptiens du Musée du Boulaq*.

² G. Maspero, *Mémoire sur quelques papyrus du Louvre*.

³ G. Möller, *Die Beiden Totenpapyrus Rhind*.

⁴ B. P. Grenfell and A. S. Hunt, *The Amherst Papyri*, II, p. 150.

⁵ W. M. Flinders Petrie, *Deshasheh*, pp. 18, 31.

⁶ A. C. Mace and H. E. Winlock, *The Tomb of Senebtisi at Lisht*, pp. 17, 18.

Ankhtifi after placing it in the second coffin and before depositing the shawls and staves.' Among the Dahshûr burials to which Mace and Winlock refer was that of King Hôr (Twelfth Dynasty) and de Morgan, describing the *sceptres* in the coffin, says they were *demi pris dans le bitume*,¹ and in the Cairo Museum there is beadwork from outside this body that is embedded in a pitch-like mass. At El-Lâhûn, Brunton, in his description of a burial, also of Twelfth Dynasty date, states² that 'The coffin was probably placed in a stone sarcophagus, as we found a lump of pitch or bitumen giving the cast of the inside at one corner and also the cast of part of the head of an anthropoid coffin, with head-dress painted in stripes of blue and gold. The pitch had been poured over the sarcophagus after the burial in order to protect it.' Brunton also found in another tomb of the same dynasty (Twelfth) at El-Lâhûn certain canopic jars, the contents of which he describes as 'bundles of cedar pitch adulterated with mud.'³ Elliot Smith, in his report on the mummy of Senebtisi, states⁴ that two of the canopic jars contained a black resinous mass. Three of the canopic jars from the so-called 'Tomb of Queen Tiye' also contained a black, very pitch-like substance that had been poured over the packets of viscera. In the case of Tut-ankhamûn, a similar-looking material had been poured in large amount over the mummy (except the head) after it had been placed in the gold coffin; over the outside of this coffin after it had been put into the next coffin and also, but only in small quantity, over the foot end of the third (outermost) coffin.⁵ A considerable amount of similar material had also been poured over the four miniature inlaid gold coffins containing the viscera after they had been placed in position in the canopic box.⁶ The remains of what is apparently a similar black or dark-brown material may be seen on the inside of the canopic box of Amenophis II, now in the Cairo Museum, and a number of large alabaster jars con-

¹ J. de Morgan, *Fouilles à Dahchour*, Mars-Juin, 1894, p. 98.

² W. M. Flinders Petrie, G. Brunton and M. A. Murray, *Labun II*, p. 29.

³ G. Brunton, *Labun I*, *The Treasure*, pp. 19-20.

⁴ G. Elliot Smith, in *The Tomb of Senebtisi at Lisht*, p. 120.

⁵ Howard Carter, *The Tomb of Tut-ankh-Amen*, II, pp. 79, 81, 83, 85, 87, 89, 90.

⁶ Howard Carter, *op. cit.*, III, pp. 49-50.

taining a similar-looking material were found many years ago by Howard Carter in the tomb of Menephtah, specimens of which he submitted to the author for analysis.

The results of the examination of these materials, taking them in the order mentioned, may now be considered.

Petrie calls the Fifth Dynasty specimen 'pitch' (probably meaning mineral pitch), but no evidence is given that it was mineral pitch and it seems highly probable that it was not analysed, and that the only reason for thinking it to be mineral pitch was because it looked like it.

Mace and Winlock call the Twelfth Dynasty specimens from the tomb of Senebtisi 'resinous material' and that from the coffin of Hapi Ankhtifi 'resin,' but neither of these were analysed. In reply to an inquiry by the author, Mr. Winlock says, 'My memory of the "resin" in Senebtisi is that it was a very dark-brown chocolate coloured material, approaching black, but not actually black.'¹

'In the case of Hapi Ankhtifi the coffin was given a coating of the coal-black and shiny pitch-like material which you know on so much of the tomb furniture from the Eighteenth Dynasty; for example, the objects from the tomb of Horemheb. After the coffin had been laid in the outer coffin and the staves had been laid upon it, the liquid "resinous" material was poured over it. It had largely disfigured the coffin and was removed some time ago, but as far as my memory serves me it also was a very dark brown.'¹

A specimen of the material from the beadwork belonging to King Hôr now in the Cairo Museum examined by the author was black, glossy and pitch-like, and analysis showed it to be probably resin, since no evidence of wood pitch or other admixture was obtained.

The Twelfth Dynasty specimen, called by Brunton 'pitch or bitumen,' from the interior of a sarcophagus at El-Lâhûn, was examined at the time by the author, who reported² that 'The sample has an aromatic odour with a slight pungency. The material is certainly not pitch (neither mineral pitch nor wood pitch), but is a resin, which at present has not been identified.'

¹ Private letter dated April 5th, 1933.

² W. M. Flinders Petrie, G. Brunton and M. A. Murray, *Labun II*, p. 15.

The 'cedar pitch adulterated with mud' from El-Lâhûn was identified by Sir Armand Ruffer, apparently from the smell, since he says,¹ 'The wood pitch was certainly cedar, and my whole laboratory has smelt of it ever since the hot weather has set in. The pitch was adulterated with very fine mud, to the extent of 10 per cent, or perhaps more.' The author made a preliminary analysis of this material at the time and found that it was almost certainly wood pitch, though more likely juniper wood pitch rather than cedar wood pitch.

The author, in his preliminary report on the material from the canopic vases of 'Queen Tiye,' stated that it 'was probably wood pitch with a mixture of fatty matter, but whether resin was present could not be determined.'²

The material from the tomb of Tut-ankhamûn has been analysed both by Plenderleith and by the author. Plenderleith states³ that the specimen submitted to him consisted of a mixture of odoriferous resins and pitch, but that he was unable to determine whether the pitch was mineral or vegetable. The specimen analysed, however, was possibly not a representative one. Thus, as shown below, the material varied from a thin, brittle substance to a thick viscous one and, although both had originally been part of the same mass, it is probable that the thin layer had not merely dried, but on account of its thinness had undergone more chemical change (especially in its content of fatty matter) than the thicker layer. Also, Plenderleith's sample was almost certainly taken from some of the material after it had been melted and that may even have been partly burned, considerable heat having been applied in order to separate the gold mask from the gold coffin to which it was stuck fast by this black material, as also to separate the gold coffin from the middle coffin, which were also stuck together.⁴

The author's preliminary report on the Tut-ankhamûn samples,

¹ G. Brunton, *Lahun I, The Treasure*, pp. 19-20.

² A. Lucas, *The Canopic Vases from the 'Tomb of Queen Tiye,'* in *Annales du Service*, xxxi (1931), pp. 120-1.

³ H. J. Plenderleith, *Appendix V*, pp. 215-16, in *The Tomb of Tut-ankh-Amen*, II, Howard Carter.

⁴ Howard Carter, *op. cit.*, II, pp. 87-8.

which were taken by himself before there had been any manipulation and which were thoroughly representative of the various portions (which differed among themselves in the proportion of the several constituents, especially fatty matter, present) was as follows¹: 'The anointing material . . . which contained fatty matter, was black and lustrous and in appearance closely resembled bitumen or pitch; where the layer was thin, as on the lid of the gold coffin, the material was hard and brittle, but between the gold coffin and the next outer one and under the mummy, where a thicker layer had accumulated, the interior of the mass was still soft and plastic. When cold there was little or no smell, but when warmed, a strong, penetrating, not unpleasant, but rather fragrant smell was evident. A detailed chemical analysis has not yet been possible, but the material contains fatty matter and resin and is entirely free from bitumen or mineral pitch. One specimen examined contained 46 per cent of fatty matter (now largely or wholly fatty acids), 19 per cent of a brown resin and a black brittle organic residue that has not been identified.'

Since this report was made, additional specimens have been examined (altogether eleven different samples), most of which definitely contained fatty matter, and only in one instance was this not found. Two of the specimens were tested for phenols, as evidence of wood pitch, but the results were negative, though some of the features of the material are strongly suggestive of wood pitch. It is certain from the manner in which the material has 'run' and from the fact that it is still viscous in places that it was either liquid or semi-liquid when used: it is equally certain that it contains fatty matter and that this cannot have been derived from the body, as is sometimes the case with the fatty matter found in resinous materials that have been in direct contact with bodies. It is well known, too, that fat was used for anointing and hence its use in this particular anointing mixture is not surprising.

The black material from outside the canopic coffins of Tut-ankhamûn is probably of the same composition as that from the large coffins and appears to consist of a mixture of fatty

¹ A. Lucas, *Appendix II*, pp. 176-8, in *The Tomb of Tut-ankh-Amen*, II, Howard Carter.

matter and resin, with certainly no mineral pitch and no clear evidence of wood pitch.

The black material from the tomb of Menephtah examined in the author's laboratory was reported as being wood pitch in two instances and resin in a third. On reviewing the analytical results in the light of greater experience of these materials, aided by the re-examination of one of the specimens (the only one left) it is found that the material resembles very closely that from the tomb of Tut-ankhamûn; it has a similar fragrant smell and contains a considerable proportion of fatty matter.

Before any final statement can be made regarding the composition of these black 'anointing' materials, a considerable amount of additional analytical work must be done, including the direct comparison of one specimen with another and with various mixtures made up for the purpose containing different proportions of resin and fatty matter, with and without wood pitch. If the material were originally black this may have been due either to the use of a resin that had been blackened (i.e. charred) during the process of heating it in order to make it sufficiently liquid for use, or to the presence of wood pitch, which is naturally black.

ONIONS

Ruffer states ¹ that 'Onions are not infrequently found among the bandages or in the coffins of mummies of the XXIst Dynasty and even as early as the XIIIth Dynasty and onion skins were sometimes placed over the eye of the dead.' Elliot Smith also found onions on mummies (often two, but sometimes only one), in the pelvis in seven cases; in the thorax in five cases; in the external ears in one case and in front of the eyes in one case,² and he states ³ that in the Twentieth, Twenty-first and Twenty-second Dynasties 'onions were used freely in the process of embalming.'

¹ Sir A. Ruffer, *Food in Egypt*, in *Mém. de l'Inst. d'Égypte*, I (1919), p. 76.

² G. Elliot Smith, *A Contribution to the Study of Mummification in Egypt*, in *Mém. de l'Inst. Égyptien*, V (1906), fasc. I, pp. 28, 31.

³ G. Elliot Smith, *The Royal Mummies*, p. 64.

PALM WINE

Palm wine has been dealt with in connexion with alcoholic beverages,¹ but both Herodotus and Diodorus state that it was employed for cleaning the body cavities and viscera during the process of embalming. This must be accepted on trust, as it is not possible that any of this wine should have remained unaltered to the present time and, therefore, it cannot be found by testing. Dawson, however, says² that 'the presence of alcohol in some of the tissues lends support to Herodotus' statement that palm wine was used for cleaning,' but no authority for the finding of alcohol is given and manifestly there is some mistake, as it is impossible that such a volatile substance should have remained. Reutter states³ that probably there had been palm wine in certain of the mummy material he examined because he found what he thought was a small amount of sugar, the presence of which, however, needs confirmation, as the test chiefly relied upon for its identification (the reduction of Fehling's solution) is not specific for sugar and is given by many other substances.

RESINS

Resins are not now among the products of Egypt and whether they ever were produced is doubtful: they occur to the north of Egypt in the countries bordering the east end of the Mediterranean; to the south in the Sudan, Abyssinia and Somaliland and to the west in Arabia, from most of which places they probably reached Egypt anciently.

As already shown in connexion with cosmetics, perfumes and incense,⁴ resin was not infrequently buried in tombs long before mummification was practised, and it was suggested that this resin was such as was being used at the time for incense. After mummification (with its accompanying considerable use of resin) became general, resin was still put in the graves, some

¹ See p. 21.

² W. R. Dawson, *Journal of Egyptian Archaeology*, XIII (1927), p. 49.

³ L. Reutter, *De l'émbaumement avant et après Jésus-Christ*, pp. 38, 50.

⁴ See p. 99.

part probably still being incense, though judging from what was found in the tomb of Tut-ankhamûn, namely, resin associated in one instance with natron, some of it was probably connected with the mummification, and, in addition, in this particular tomb there were personal ornaments and other objects made of resin and resin was also used as a varnish and as a cementing material; in this tomb, too, which it should not be forgotten was a royal one, the incense no longer consisted of true resin from Asia, but of the more odoriferous and probably much more rare and costly gum-resin from the south.¹

As it is the subject of mummification that is now being dealt with, only those resins that have been found directly associated with mummies will be considered, all resins of the Badarian, predynastic and early dynastic periods before the introduction of mummification being omitted.

In the literature of Egyptology there are many precise statements regarding the nature of the resins used in ancient Egypt, particularly for mummification, but many of these are merely guesswork, the nature of these resins having been very little investigated and very few of them having been identified with certainty. The only comparatively recent serious attempts to study the nature of these resinous materials, of which the results have been published and can be traced, are an analysis by Professor Florence of Lyons,² the work of Dr. Louis Reutter³ and the work of the author.⁴

Florence, as the results of his analysis, concluded that the resin he examined, which was from the grave of a monkey (undated), was some kind of pine resin, though he was unable to give the particular species.

Reutter analysed six specimens of Egyptian mummy material,³ three from human mummies (one of the Thirtieth Dynasty and two undated); one from an ibis mummy; one (consisting of a bundle of bandages) from bird mummies (undated) and

¹ A. Lucas, in *The Tomb of Tut-ankh-Amen*, Howard Carter, II, pp. 183-4; III, pp. 181-2.

² Quoted by Lortet and Gaillard in *La faune momifiée de l'ancienne Égypte*, I (1905), pp. 319-21.

³ For reference, see p. 236.

⁴ A. Lucas, *Preservative Materials used by the Ancient Egyptians in Embalming*, 1911.

one from a canopic box (undated). While recognizing the importance of this work and without in any way wishing to depreciate its value or to impugn the accuracy of the analyses, the author would like to suggest that some of the interpretations of the results may be erroneous. The first striking fact is the comparatively large number of different substances in each specimen of material examined, thus in one specimen he found storax; Aleppo resin; mastic; cedar resin; certain resins not identified; bitumen and sugar; in a second, certain resins not identified; gum or gum-resins; storax; wood pitch; bitumen; balsam of Illurin or Mecca balsam and sugar: in a third, bitumen; sugar; wood pitch; balsam of Gurjun and possibly balsam of Illurin or Mecca balsam: in a fourth, bitumen; myrrh; possibly aloes and probably balsam of Judea: in a fifth, bitumen; myrrh; aloes and probably Mecca balsam and in a sixth, bitumen; cedar resin; the resin from *Pistacia terebinthus* and sugar. This is quite contrary to the author's experience and of the very large number of different specimens of resinous materials he has examined from all periods, by far the greater number have been homogeneous resins or gum-resins of well defined character and only in a comparatively few instances have they been mixtures and then with fatty matter.¹

The tests relied upon by Reutter for the identification of bitumen² and sugar³ respectively have already been discussed: the tests for storax and wood pitch are satisfactory ones. For the other materials Reutter in many cases made an 'ultimate analysis,' determining the carbon and hydrogen by direct experiment and estimating the oxygen by difference (the usual method), and from the results obtained he calculated the percentage of the three elements present and from this he calculated a formula for the substance, which he then identified with the formula of a known substance. When, however, the smallness of the portion of material operated upon (from 0.02 to 0.22 gram), which did not permit of a duplicate analysis as a check, the multiplication and division of the original figures necessitated by the calculations and the fact, to take one example, that 77.42

¹ A. Lucas, *Preservative Materials used by the Ancient Egyptians in Embalming*, 1911.

² See p. 236.

³ See p. 258.

per cent of carbon and 10.43 per cent of hydrogen represent one substance (*gurjorésène*), and 77.3 per cent of carbon and 10.2 per cent of hydrogen represent a totally different substance (*masticorésène*), and the further facts that while 71.5 per cent of carbon and 8.6 per cent of hydrogen and 71.19 per cent of carbon and 8.64 per cent of hydrogen respectively represent the same substance (*B-beerabomyrrhol*), 71.0 per cent of carbon and 8.79 per cent of hydrogen represent a different substance (not identified), and 71.6 per cent of carbon and 8.05 per cent of hydrogen still another substance (not identified), one may be pardoned for thinking there is room for mistakes in identification. In several instances, too, Reutter bases a probable identification upon the smell of the material, or upon a process of exclusion, assuming that because negative results were obtained when certain specific resins were tested for and hence were presumably absent, therefore another resin, that it was thought might have been used, was probably present.

The author has examined a very large number of resinous materials from mummies,¹ the results of which may now be considered. Reutter, in his criticism of this work, suggests that 'ultimate analyses' should have been made; but unfortunately, as explained at the time, this was not possible, partly because of the small size of the specimens and also because of the lack of the necessary time and facilities. In those cases, too, in which the material had become contaminated with natron or with fatty or other decomposition products of the body, or had intentionally been mixed with fatty matter which were a large proportion of the total number, any 'ultimate analysis' would have been, not only useless, but misleading. Since the original report was published, some of the same materials have been re-examined in greater detail and other specimens have been analysed. These resinous materials may be classified into two main groups, namely, true resins and gum-resins, which may separately be considered.

True Resins

One of the most noticeable features of the true resins is the considerable difference in colour among them, some being

¹ A. Lucas, *op. cit.*

reddish (almost orange-coloured and giving a yellow powder when finely ground); others black and pitch-like in appearance; others brown and one a slate colour.

Of the reddish material, eleven specimens from mummies have been examined, seven of which were from the cranial cavity, three from the orbits and one from the nose, four being of the Twenty-first Dynasty and the others undated, but almost certainly late. The botanical source of this resin has not been identified. A resin, almost identical in appearance with the eleven specimens mentioned and having a very similar solubility in various solvents, was found in the tomb of Tutankhamûn in a vase in the same 'kiosk' as another vase containing natron and this resin, therefore, may have had a direct connexion with the embalming.

Of the pitch-like material eleven specimens have been examined, five from human mummies (one Eighteenth Dynasty; one Twenty-first Dynasty, and three Ptolemaic); one from a crocodile mummy (undated) and five from graves (all Ptolemaic), but it is not known whether these latter were taken from the mummy or not. Four of the specimens are reported by Spielmann to contain bitumen, but as two of them are without one or two of the tell-tale elements (vanadium, nickel and molybdenum) characteristic of bitumen this seems improbable, and the author thinks that the presence of bitumen even in the other two has not been proved.¹ The botanical source of these black resins has not been identified.

It has not been found possible to determine the cause of the black colour, nor whether the material was originally black or has become black with age, but one of the specimens, though generally black and lustrous and very pitch-like, was in part a deep brown colour and in one corner almost ruby-red, and it would seem possible, therefore, for a resin, not originally black, to become black. Of the eleven specimens mentioned, nine contained fatty matter, and it has previously been suggested that possibly the presence of fatty acids from the body may have caused certain resins to become black.² Another possibility is that the black colour may have been caused by the material having been charred during the heating to which it was probably

¹ See pp. 237-9.

² A. Lucas, *op. cit.*, p. 46.

subjected in order to render it sufficiently liquid to enable it to be poured over the body or into the body cavities, as the case might be.

Other black mummy materials are described in connexion with ointments and wood tar respectively.¹

The brown specimens and the slate coloured one were ordinary resinous-looking materials, of which it has not been possible to determine the botanical source.

Gum-Resins

The author has examined nine specimens of what proved on analysis to be gum-resins, all from mummies and five of them from royal mummies (two Eighteenth Dynasty, one Nineteenth Dynasty; two Twentieth Dynasty, three Twenty-first Dynasty and one Ptolemaic). These are believed to be either bdellium or myrrh (which are closely allied and very similar) and most probably myrrh.

Both Herodotus and Diodorus mention the employment of myrrh for mummification: Pettigrew states² that 'Dr. Granville found . . . two or three small pieces of myrrh in their natural state,' and that 'Dr. Verneuil says he has been able to recognize myrrh among the balsamic substances employed in embalming,' both of which identifications appear to be largely of the nature of guesswork: Reutter reports myrrh as being present in two specimens of mummy material he analysed, one from human vertebræ and the other from a human hand, both undated.³ Myrrh has already been described in connexion with incense.⁴

Certain miscellaneous resins may now conveniently be dealt with. In one of the mummy materials examined by Reutter there were small fragments of a yellowish-brown somewhat transparent resin having an odour of turpentine, which was picked out, analysed separately and identified as probably Chios turpentine.⁵ The slight solubility in alcohol, the high saponification value and the high melting point, however, are all

¹ See pp. 251, 267.

² T. J. Pettigrew, *op. cit.*, p. 60 n.

³ L. Reutter, *De la Momie ou Mumia*, in *Bull. des Sciences Pharmacologiques*, Paris, no date, pp. 49, 58.

⁴ See p. 94.

⁵ L. Reutter, *De l'embaumement avant et après Jésus-Christ*, pp. 35, 36, 48.

against this. Holmes also identified as Chios turpentine a specimen of resinous material found by Petrie in a jar at Naukratis, which was dated to about the sixth century B.C.¹ Chios turpentine is an oleo-resin obtained from *Pistacia terebinthus* that grows in southern Europe, Asia Minor, Syria and North Africa and is often called the 'turpentine tree' from the large amount of oleo-resin (turpentine)² that is obtained from it; and it was possibly the product from this tree to which the name of turpentine was first applied and, since the greater proportion of this material at one time on the market was collected from the island of Chios in the Grecian archipelago, it was named Chios turpentine. Holmes also examined a specimen of resinous material from a sarcophagus found at Hawara, dating from the second century A.D., but on account of the very small amount of material available, only few tests were possible, as the result of which he suggested that it was either benzoin or storax and probably the former.³ That it was one or the other seems certain, since benzoic acid was given off when it was heated and, although benzoin is obtained from the Far East (Siam, Sumatra, Borneo and Java) there would not have been any insuperable difficulty in its reaching Egypt at the late date mentioned, and benzoin is a well known incense material in the East at the present day.

Resin was employed, not only on the mummy, but for other purposes in the tomb; thus it was used for securing in place the metal bolts of the granite sarcophagus of Chephren⁴; it was found on the rebated edge of the gold coffin of Tut-ankhamûn, having apparently been used to lute on the lid and so make a tight joint⁵; it was used on a Twenty-sixth Dynasty sarcophagus

¹ E. M. Holmes, *The Pharmaceutical Journal*, xix (1888-9), pp. 387-9.

² The original name of the natural oleo-resinous exudation from the *Pistacia terebinthus*, as also from pines and certain other coniferous trees was turpentine, and it is only comparatively recently that the name of the oil (spirit) prepared from it became shortened from oil of turpentine (spirits of turpentine) to turpentine and the natural product is still called turpentine scientifically, and certain kinds are still known as turpentine commercially, for example, Chios turpentine, Venice turpentine and Strasburg turpentine.

³ E. M. Holmes, *op. cit.*, pp. 387-9.

⁴ W. M. Flinders Petrie, *The Pyramids and Temples of Gizeh*, p. 106.

⁵ Examined by the author.

found by Firth at Saqqâra 'to support the lid just before it settled in position,'¹ and it was present between the lid and box of a coffin, probably also from Saqqâra, of which the particulars cannot now be traced.² In all these four instances the resin had a utilitarian purpose.

But resin was also employed where it served no useful purpose and where, therefore, it probably had a ritual significance. Thus in a Twenty-sixth Dynasty tomb at El-Matarieh near Cairo³ a large quantity (more than 50 kilograms) of resin was found between the sarcophagus (which is made of the light coloured blue-grey schist from the Wâdi Hammamât, so much employed at this period) and the walls of the large hollowed-out monolithic 'case' of limestone into which the sarcophagus closely fitted. From the results of the analysis of the resin, which have been published elsewhere,⁴ it is believed to be Chios turpentine. Three other examples of the similar use of resin have come under the author's notice,⁴ namely, (a) small patches of an identical-looking resin on the sides of a similar sarcophagus to that just described and of the same period in the British Museum⁵; (b) a mixture of resin and limestone dust used to fill up the space between a sarcophagus and an inner coffin of Twenty-sixth Dynasty date from Saqqâra⁶ and (c) a mixture of resin and broken quartz pebbles used to fill up the space between a granite coffin and a wooden one of late date from Saqqâra.⁷ The limestone dust and quartz pebbles respectively were probably used in order to economize resin.

SALT

The occurrence and use of salt in ancient Egypt has already been described in connexion with minerals⁸ and the subject

¹ Described by C. M. Firth and examined by the author.

² Examined by the author.

³ Tomb No. 6 described by H. Gauthier (*Découvertes récentes dans la nécropole Saïte d'Héliopolis*, in *Annales du Service*, xxxiii (1933), pp. 27-53; Pl. VI).

⁴ A. Lucas, *Resin from a Tomb of the Saïte Period*, in *Annales du Service*, xxxiii (1933), pp. 187-9.

⁵ Called 'Grey basalt coffin of Wah-Ab-Ra' and stated to have come from Campbell's tomb, *Giza*, No. 1384.

⁶ Submitted by C. M. Firth and examined by the author.

⁷ Found by J. E. Quibell at Saqqâra.

⁸ See p. 228.

of its use in mummification has been discussed by the author elsewhere,¹ and in his opinion there is no evidence that salt, either solid or in solution, was employed in embalming until the early Christian period, and then not to the best advantage, but only in comparatively small amounts often placed, not in contact with the body, but outside or between the clothes or wrappings, where any effect must have been almost negligible, and its use may possibly have been ritualistic or conventional, rather than practical. The presence of salt in small quantity on mummies of earlier periods can be satisfactorily explained by the fact that the natron employed always contained salt. Six specimens of salt from bodies of the early Christian period (five from the fifth or sixth century and one termed 'Coptic,' of which the date was not given) have been analysed and found to be very pure salt containing from 92 to 98 per cent of sodium chloride and to be quite free from alkali, and, therefore, they had not been obtained from the immediate neighbourhood of any natron deposit.²

SAWDUST

Elliot Smith and Dawson state³ that sawdust, both alone and mixed with resin, has been found in the body cavities of mummies and that in one instance the skin was sprinkled with powdered aromatic wood or sawdust; in the chest cavity of the mummy of Senebtisi (Twelfth Dynasty) Elliot Smith found sawdust⁴; Verneuil found a canopic vase he examined filled with what he describes as cedar dust and natron⁵; Winlock found sawdust on several occasions among refuse embalming material from El-Deir el-Bahari,⁶ one specimen of which (from

¹ A. Lucas, *The Use of Natron in Mummification*, in *Journal of Egyptian Archaeology*, xviii (1932), pp. 127-9.

² A. Lucas, *Preservative Materials used by the Ancient Egyptians in Embalming*, p. 20.

³ G. Elliot Smith and W. R. Dawson, *op. cit.*, pp. 81, 84, 114, 115, 117, 118.

⁴ G. Elliot Smith in *The Tomb of Senebtisi at Lisht*, A. C. Mace and H. E. Winlock, p. 119.

⁵ de Verneuil, in *Catalogue des Antiquités découvertes en Égypte*, J. Passalacqua, p. 286.

⁶ H. E. Winlock, *op. cit.*, 1922, p. 34; 1928, p. 25.

the Eleventh Dynasty tomb of Ipi) was examined by the author ; in another case some material tied up in a piece of woven fabric from a Twelfth Dynasty tomb found by Winlock at El-Deir el-Bahari, consisted of a mixture of fine sawdust and quartz sand¹ ; among the refuse embalming material from the tomb of Yuya and Thuyu (Eighteenth Dynasty) there was at least one large jar containing a mixture of resin and sawdust.² Some of the sawdust examined by the writer has been fragrant and possibly, therefore, juniper-wood sawdust.

SPICES

The use of spices in mummification is referred to by both Herodotus and Diodorus, but in neither instance is there any indication of the kind employed. Apart from the finding of what may have been cassia or cinnamon,³ no reference can be traced to the presence of spices in mummies.

WOOD PITCH AND WOOD TAR

Wood pitch and wood tar may be classed together, as they are very closely connected both in composition and in method of production, wood tar being a thick, black liquid of complex constitution produced by the destructive distillation of resinous wood, and wood pitch being the solid residue left when the liquid tar is distilled for the recovery of certain volatile constituents contained in it (chiefly acetic acid, methyl alcohol, oils and creosote).

Wood tar was known to the Greeks of the time of Theophrastus⁴ (fourth to third century B.C.) and to the Romans of Pliny's day⁵ (first century A.D.) since both these writers, who term the material 'pitch' (Pliny also calling it 'liquid pitch'), describe a primitive method of producing it. Hence, that wood tar or wood pitch should have been known to, and used by, the Egyptians, especially at a late date, is not surprising.

¹ Submitted by Dr. Derry and examined by the author.

² J. E. Quibell, *The Tomb of Yuaa and Thuiu*, in *Cat. Gén. du Musée du Caire*, pp. 75-7.

³ See p. 239.

⁴ *Enquiry into Plants*, IX, 3, 1-3.

⁵ XVI, 21-2.

Reutter found wood tar (*goudron de bois*) in ancient Egyptian materials on two occasions, one on the mummy of an ibis (undated) and the other in the resinous material from a funerary vase (undated).¹

Ruffer has already been quoted for the identification of 'cedar-wood pitch' of Twelfth Dynasty date from El-Lâhûn,² which the author also examined and suggests that, although wood pitch, it was probably juniper-wood pitch and not cedar-wood pitch.

A number of specimens of ancient embalming material, chiefly from Ptolemaic mummies and often from inside the skull, which the author has examined are believed to be wood pitch. Particulars of a few of these were published several years ago³ and others have been examined since.

Although wood tar is a secondary product obtained during the process of making charcoal, which was one of the important minor industries in ancient Egypt, there is no evidence that the tar produced was collected and utilized and, as the material found on, or in connexion with, mummies, is often fragrant and therefore almost certainly from coniferous woods (frequently probably juniper) which do not grow in Egypt, it seems highly probable that the wood tar or wood pitch used was imported and not produced locally.

¹ L. Reutter, *De l'embaumement avant et après Jésus-Christ*, pp. 56, 59, 66, 68.

² See p. 255.

³ A. Lucas, (a) *Preservative Materials used by the Ancient Egyptians in Embalming*, pp. 43, 46, 49; (b) in *Journal of Egyptian Archaeology*, I (1914), pp. 244-5.

CHAPTER IX

OILS, FATS AND WAXES

Although fatty matter has frequently been found in Egyptian tombs, it has seldom been analysed, and of the few analyses of which any record can be traced none is conclusive. This inconclusiveness is inevitable as all oils and fats, unless kept under special air-tight and sterile conditions, which is not the case when placed in jars in tombs, sooner or later decompose, and as some of the bodies formed escape, either by evaporation or by soaking into the material of the containing vessel, all that the analyst has for examination, although often still looking and feeling like a fat, is merely a portion of the products of decomposition, consisting generally of a mixture of certain bodies termed 'fatty acids,' principally the solid acids, palmitic and stearic; and it is only by the separation, purification and identification of these and by a determination of the proportion in which each occurs in the mixture that the nature of the original oil or fat can sometimes be ascertained; and since what remains is generally only a part of that formed, and not necessarily a representative part, the problem may often be insoluble.

The only analyses of fatty material from Egyptian tombs that can be traced are those by Ure,¹ Friedal,² McArthur,³ Chapman and Plenderleith,⁴ Thomas,⁵ Banks and Hil-

¹ Quoted by J. G. Wilkinson, *The Ancient Egyptians*, 1878, II, p. 401.

² Quoted by E. Amélineau, *Les nouvelles fouilles d'Abydos*, 1895-6, pp. 275-80.

³ Quoted by W. M. Flinders Petrie and J. E. Quibell, *Nagada and Ballas*, p. 39.

⁴ A. C. Chapman and H. J. Plenderleith, *Examination of an Ancient Egyptian Cosmetic*, *J. Chem. Soc.*, 1926, pp. 2614-19; also in *The Tomb of Tut-ankh-Amen*, Howard Carter, II, Appendix IV, pp. 206-10.

⁵ Quoted by A. Lucas in Appendix II, *The Tomb of Tut-ankh-Amen*, II, Howard Carter, pp. 177.

ditch¹ and the author,² which may now be discussed, the most complete study of the subject being that of Banks and Hilditch.

Ure's analysis is wholly inconclusive, but in the other cases the material was found to consist largely of palmitic acid³ or stearic acid³ or of a mixture of the two, with, in some instances, small proportions of other fatty acids, of which oleic, myristic, azelaic and nonoic acids have been identified.⁴ These results indicate that the particular specimens examined had originally probably been animal fats, which is confirmed in at least one instance by the archæological evidence, which proves that the material had been in a more or less solid condition and not a liquid oil.⁵

Banks and Hilditch point out that the results found make it most improbable that any of the specimens had originally been castor oil, which previous to their work had been suggested for three specimens (once by Friedel, once by Thomas and once by the author), since the principal constituent of castor oil is a variety of oleic acid (in the combined state) and since the oleic acid, which must have been contained in all the other specimens (oleic acid being a constituent of most fixed oils and solid fats, particularly the former) had wholly or largely disappeared.

The strong smell, reminiscent of rancid coconut oil, frequently noticed in the ancient fatty materials, has led to the suggestion that the original fat had been coconut oil,⁵ and the presence of palmitic acid has been taken to indicate an original palm oil,⁵ but both these suppositions are demonstrably wrong, the smell being due to a very small proportion of nonoic acid, which

¹ A. Banks and T. P. Hilditch, *A Note on the Composition of some Fatty Materials found in Ancient Egyptian Tombs*, in *Analyst*, 1933, pp. 265-9.

² A. Lucas, Appendix II, *The Tomb of Tut-ankh-Amen*, II, Howard Carter, pp. 176-7; also in *J. Egyptian Archaeology*, XVI (1930), pp. 46-7.

³ Both palmitic and stearic acids are solid, white, tasteless and odourless bodies that are present in the combined state in most animal and vegetable oils and fats and form important constituents of the harder fats.

⁴ In one instance succinic acid was present, but this was probably derived from some non-fatty material (almost certainly resin) mixed with the original fat.

⁵ W. M. Flinders Petrie and J. E. Quibell, *Nagada and Ballas*, pp. 39-40.

has been formed as the result of decomposition, and palmitic acid being a constituent of most animal and vegetable oils and fats.

In the hieroglyphic records of ancient Egypt, although oils and fats are frequently mentioned, either their nature is often not stated or the meaning of the word used to describe them is unknown, and in consequence it has not yet been possible to translate many of the names, the only ones of which a translation is given by Breasted being goose fat and ox fat.¹

The papyri of the Graeco-Roman period, written in Greek and found in the Fayûm province, also frequently refer to oils, the Greek names of most of which are well known. The oils mentioned are castor oil^{2, 3} (termed both *cici* oil and croton oil, though manifestly it cannot have been the modern croton oil); cedar oil⁴; colocynth oil²; linseed oil²; olive oil⁵; radish oil (*raphanus* oil^{5, 6}); safflower oil² (termed *cnecus* oil and *cnecinum* and thought by Grenfell and Wright to be from the seeds of the thistle or artichoke) and sesame oil.²

The classical writers refer to the use in Egypt of almond oil⁷; *balanos* oil^{8, 9}; ben oil¹⁰; castor oil^{11, 12, 13, 14}; cedar oil¹⁵; olive oil^{16, 17, 18}; radish oil¹⁴; and several others of which the identification is uncertain.

The various oils and fats mentioned will now separately be described, which may conveniently be done in alphabetical order.

¹ J. H. Breasted, *op. cit.*, v (Index), pp. 123, 149.

² B. P. Grenfell, *Revenue Laws of Ptolemy Philadelphus*, pp. xxxvi, 124, 126, 129, 135, 157.

³ B. P. Grenfell and A. S. Hunt, *The Hebeh Papyri*, I, pp. 320-3.

⁴ B. P. Grenfell and A. S. Hunt, *The Oxyrhynchus Papyri*, xvi, pp. 202-3; *The Amherst Papyri*, II, p. 150.

⁵ B. P. Grenfell, A. S. Hunt and D. G. Hogarth, *Fayûm Towns and their Papyri*, pp. 234-7; B. P. Grenfell and A. S. Hunt, *The Amherst Papyri*, II, p. 150.

⁶ B. P. Grenfell and A. S. Hunt, *op. cit.*, VI, pp. 303-5; xvi, pp. 60-1.

⁷ Pliny, XIII, 2.

⁸ Pliny, XIII, 2.

⁹ Theophrastus, *Concerning Odours*, 15, 19.

¹⁰ Pliny, XII, 46.

¹¹ Herodotus, II, 94.

¹² Diodorus, I, 3.

¹³ Strabo, XVII, 2, 5.

¹⁴ Pliny, XV, 7.

¹⁵ Herodotus, II, 87.

¹⁶ Theophrastus, *Enquiry into Plants*, IV, 2, 9.

¹⁷ Strabo, XVII, I, 35.

¹⁸ Pliny, XV, 4.

Almond Oil

Pliny mentions the manufacture in Egypt of an unguent, the Mendesian unguent, containing oil of bitter almonds, which he says was expressed in Egypt.¹ If this were so, the almonds used were almost certainly imported, for although the almond tree grows in the country, it is comparatively rare, being only cultivated at the present day in gardens in the Delta. This statement of Pliny's is the only reference that can be traced respecting the use of almond oil in ancient Egypt. The almond fruit, however, was certainly known to at least some, though probably only a slight, extent since it has occasionally been discovered in tombs, the earliest known being of Eighteenth Dynasty date.² Other examples that may be mentioned are four specimens identified by Newberry from the Ptolemaic cemetery at Hawara³ and nine that have been in the Cairo Museum for many years, of which neither the place of origin nor date can now be traced.

Animal Fats

Since the ancient Egyptians kept cows, sheep and goats, it is only natural that they should have been acquainted with the fat of these animals, including milk fat, and fats are mentioned in the ancient records, namely, 'butter' (Twentieth Dynasty⁴); ox fat (Eighteenth Dynasty⁵); white fat (Twentieth Dynasty, on one occasion being 'for cakes'⁶); and goose fat (New Kingdom and Twentieth Dynasty^{7, 8}).

The author suggests that the translation 'butter' is almost certainly wrong, the word so translated meaning probably not butter, but butter fat, the distinction between the two being a very real one. Butter is the material produced by churning

¹ XIII, 2; XV, 7.

² That of Tut-ankhamûn, not yet published.

³ P. E. Newberry, *The Ancient Botany*, in *Kahun, Gurob and Hawara*, W. M. Flinders Petrie, p. 47.

⁴ J. H. Breasted, *op. cit.*, IV, 233, 301, 344, 350, 376.

⁵ II, 293.

⁶ IV, 233, 239, 299, 300, 350, 376.

⁷ A. Erman, *The Literature of the Ancient Egyptians*, trans. A. M. Blackman, p. 210.

⁸ J. H. Breasted, *op. cit.*, IV, 233, 376.

milk or cream until the individual globules of fat previously in suspension coalesce ; and though the fat is separated from the greater part of the liquid by pressing and straining, a certain amount of water and casein remain entangled with it (generally about one-fifth, or 20 per cent of the whole), and the water naturally contains a proportion of the sugar and mineral constituents of the original milk. Butter fat, on the other hand, is made by melting butter and allowing it to stand until the water and casein settle out, when the fat is poured off, and it is this that constitutes the modern Egyptian *samn* and the Indian *ghi*, which are used for eating with food and for cooking, but are never spread on bread in the manner of butter, which is entirely a custom of cold countries. The separation of butter fat from butter is a natural and unavoidable occurrence in a hot country like Egypt, especially in the summer, and the separated fat keeps much better than the original butter.

As already stated, a number of the specimens of the fatty matter from tombs that have been analysed had probably originally been solid animal fat, but so far there has been nothing characteristic left that would indicate from what particular kind of animal they had been derived and it is impossible to say, for example, whether they were ox fat or sheep fat, but since it is known from the records that ox fat was largely used, this is the more probable.

The use of a mixture of the fat of various animals, including goat fat, is mentioned in the Papyrus Ebers (about 1500 B.C.) as a remedy against baldness,¹ and goose fat is an ingredient in several remedies.¹

Balanos Oil

Balanos oil, which is not now known in Egypt, was the oil expressed from the 'stones' (which are found enclosed in a fleshy fruit) of *Balanites aegyptiaca*, a tree that at one time was abundant in Egypt, but which is now rare even in Upper Egypt and still more so in the Delta, where only a few specimens occur in gardens, though it grows plentifully in the Sudan and in Abyssinia.

¹ C. P. Bryan, *The Papyrus Ebers*.

Theophrastus states¹ that the *balanos* was an Egyptian tree, so named from the fruit because this was shaped like an acorn (*balanos*²) and that the oil chiefly used in Greece for making perfumed ointments was that of the Egyptian or Syrian *balanos*,³ the former being the more receptive and keeping the longer and, therefore, being the more suitable for choice perfumes. Pliny states⁴ that oil of *balanus* was one of the ingredients of the Mendesian unguent.

The fruits and 'stones' have frequently been found in Egyptian tombs and there are a number in the Cairo Museum stated to have been obtained from Gebelein, but unfortunately the date is not recorded.

Ben Oil

Ben oil is the oil expressed from the nuts of *Moringa pterygosperma* (*M. oleifera*) and *Moringa aptera*, the oil from the two species being practically identical.⁵ *Moringa aptera* is a small tree that grows in Egypt at the present time and is probably indigenous to the country. The refined oil has a yellowish colour, a sweet taste and is odourless and does not easily become rancid, for which reason it is much esteemed in the East for making perfumery. The nut, which is somewhat like a hazel nut, contains a large white oily seed, which not only is grown locally, but which is also imported into Egypt from Ceylon and southern India and is eaten by women who wish to grow fat.⁶

Ten seeds of *Moringa aptera* were identified by Newberry from the Ptolemaic cemetery at Hawara.⁷

Castor Oil

The castor oil plant grows wild in Egypt at the present day and, since the seeds have been found in graves as early as the Badarian period,⁸ the plant is possibly indigenous in the country.

¹ *Enquiry into Plants*, IV, 2, 1; IV, 2, 6.

² It is an oblong fruit, in appearance very like a small, smooth, fresh date.

³ *Concerning Odours*, 15, 16, 19.

⁴ XIII, 2.

⁵ Anon., *Bulletin, Imperial Institute*, 28 (1930), pp. 276-9.

⁶ A. H. Ducros, *Essai sur le droguier populaire arabe de l'inspectorat des pharmacies du Caire*, in *Mém. de l'Inst. d'Égypte*, 1930, xv, pp. 39, 40.

⁷ P. E. Newberry, in *Kahun, Gurob and Hawara*, W. M. Flinders Petrie, p. 47.

⁸ G. Brunton and G. Caton-Thompson, *The Badarian Civilisation*, pp. 38, 41.

Herodotus,¹ Diodorus,² Strabo³ and Pliny⁴ all mention the use in Egypt of castor oil for burning in lamps. Herodotus states that the seeds were either bruised and pressed, or roasted and boiled, in order to obtain the oil, which had a strong smell : Strabo states that the oil was used by the poorer people and labourers, both men and women, for anointing the body : Pliny says that in Egypt the oil was extracted without employing either fire or water, the seeds being first sprinkled with salt and then pressed.

Both castor oil and castor berries figure largely in the pharmacopoeia of ancient Egypt and are frequently mentioned as medicine in the Papyrus Ebers⁵ : the oil is still largely used as a medicine at the present day and in Nubia it is also used for anointing the body and dressing the hair.

Cedar Oil

The tree, the name of which is usually translated cedar, was probably not the cedar, or at any rate not always the cedar, but often the juniper, or other conifer,⁶ but whether cedar or juniper, the oil called cedar oil cannot have been a fixed oil pressed from the seeds or fruits, but must have been a volatile (essential) oil obtained by steeping or boiling some part of the particular tree in a fixed oil,⁷ that is to say, 'cedar oil' was some ordinary oil (Theophrastus states that olive oil, almond oil or oil of *balanos* was generally used as a base for perfumes⁸) perfumed by the odoriferous principle from the cedar or juniper, as the case might be. The present day oil of cedar is a product obtained by distillation (a method not known until a late date) from the American juniper (*Juniperus virginiana*).

Colocynth Oil

The colocynth grows wild in Egypt, principally in the desert and largely in Sinai, but it is also cultivated to a slight extent for the fruit, which contains an active principle that has con-

¹ II, 94.

² I, 3.

³ XVII, 2, 5.

⁴ XV, 7.

⁵ C. P. Bryan, *The Papyrus Ebers*.

⁶ A. Lucas, 'Cedar'-Tree Products employed in Mummification, in *Journal of Egyptian Archaeology*, XVII (1931), pp. 13-21.

⁷ See p. 241.

⁸ Concerning Odours, 14-16.

siderable medicinal use. The seeds when pressed yield an oil, which is not now used in Egypt.

Lettuce Oil

The lettuce is largely cultivated in Egypt, and in Upper Egypt especially, for the sake of the oil obtained from the seeds, which is used as a salad oil and in cooking.

Linseed Oil

Flax was extensively grown in Egypt from a very early date for the sake of the fibre for making linen and probably, therefore, linseed oil (which is the oil expressed from the seeds of the flax plant) was also known at an early date, though the first record of it that can be traced is of the Ptolemaic period.¹ It was probably used for cooking and for burning in lamps, for which purposes it is still employed by the poorer classes in Egypt. The principal present day value of linseed oil is, however, as a paint oil, on account of its drying properties, but it was not employed for this purpose in Egypt, or elsewhere, so far as is known, even as late as the Roman period.

Olive Oil

In the hieroglyphic records of ancient Egypt olive trees and olives are seldom mentioned and olive oil possibly not at all,² thus all that can be found in the accessible translations are four references to olive-lands in the Twentieth Dynasty^{3, 4} and five references to olives, one of New Kingdom date⁵ and four from the Twentieth Dynasty,⁶ and a copy of a fragment of a mural painting of the Eighteenth Dynasty showing a small part of an olive tree with several olives growing on it.⁷

¹ See p. 271.

² In one place (*op. cit.*, III, 208) Breasted translates tentatively an uncertain word in a Nineteenth Dynasty text as olive oil.

³ J. H. Breasted, *op. cit.*, IV, 216, 263, 288, 394.

⁴ In one place (*op. cit.*, II, 449) Breasted translates tentatively two uncertain words in an Eighteenth Dynasty text as olive wood.

⁵ A. Erman, *The Literature of the Ancient Egyptians*, trans. A. M. Blackman, p. 206.

⁶ J. H. Breasted, *op. cit.*, IV, 239, 241, 379, 393.

⁷ Nina de G. Davies, in *The Mural Painting of El-Amarna*, Pl. IX (c).

The classical writers supply additional information respecting the olive tree in Egypt, thus Theophrastus (fourth to third century B.C.) states ¹ that the olive tree grew in the Thebaid and that 'The oil produced is not inferior to that of our country, except that it has a less pleasing smell . . .' Strabo (first century B.C. to first century A.D.) says ² of the Arsinoite Nome (the Fayûm) that 'It is the only nome planted with large, full-grown olive trees, which bear fine fruit. If the produce were carefully collected, good oil might be obtained, but this care is neglected, and although a large quantity of oil is obtained, yet it has a disagreeable smell. (The rest of Egypt is without the olive tree, except the gardens near Alexandria, which are planted with olive trees, but do not furnish any oil).' Pliny (first century A.D.) writes ³ that 'In Egypt, too, the berries, which are remarkably meaty, are found to produce very little oil.'

Mahaffy ⁴ and Grenfell ⁵ both point out that in the legislation of Ptolemy Philadelphus (285 to 246 B.C.) concerning oils and oil-pressing in Egypt there is not any reference to olive oil, commenting upon which Bevan says, ⁶ 'Olive trees grew in the Fayum, but olive oil does not seem to have been included in the monopoly.' The reason is not apparent, though it might possibly have been that the oil produced was too insignificant in quantity to be legislated for. Olives are mentioned in the Fayûm about 257 B.C. ⁷; olive oil in the second century A.D. ⁸ and olive-yards on several occasions ranging in date from A.D. 94 to A.D. 110. ⁹ The mere mention of olive oil, however, is not proof that it was of Egyptian origin, since this oil was imported into Egypt from Syria and Greece, particularly at a late date. C. R. Scott, writing in 1837, that is during the reign of Mohammed Ali, states ¹⁰ that 'Vast tracts of land

¹ *Enquiry into Plants*, IV, 2, 9.

² XVII, 1, 35.

³ XV, 4.

⁴ J. P. Mahaffy, in *Revenue Laws of Ptolemy Philadelphus*, B. P. Grenfell, p. xxxv.

⁵ B. P. Grenfell, *op. cit.*, p. 125.

⁶ E. Bevan, *A History of Egypt under the Ptolemaic Dynasty*, p. 149 n.

⁷ B. P. Grenfell and A. S. Hunt, *The Hibeh Papyri*, pp. 192-3.

⁸ B. P. Grenfell, A. S. Hunt and D. G. Hogarth, *Fayûm Towns and their Papyri*, pp. 234, 237.

⁹ B. P. Grenfell, A. S. Hunt and D. G. Hogarth, *op. cit.*, pp. 261-74.

¹⁰ C. R. Scott, *Rambles in Egypt and Candia*, II, 1837, p. 166.

have been planted in various parts of the country with olive and mulberry trees.' In 1901, G. Bonaparte, of the School of Agriculture, Cairo, states¹ that the olive tree was only cultivated in Egypt to a very limited extent, chiefly in the Fayûm and that the fruits were poor in oil. In 1927, Newberry writes² that the olive tree 'is only cultivated in a very few gardens in Upper Egypt at the present day.' Ruffer saw a few, but only very few, olive trees in the oases of the western desert.³ According to the local press, the Egyptian Government has recently planted a considerable number of olive trees in the country to the west of Alexandria.

The facts enumerated seem to show that, although the olive tree grows abundantly in the countries on all sides of Egypt (across the Mediterranean to the north in Anatolia and Greece : on the north-east in Palestine and Syria : on the south in Abyssinia, where there are two kinds that grow wild, and on the west in Tunis and Algeria the Maurusia of the Greeks and the Mauretania of the Romans), it has never accommodated itself well to the conditions in Egypt, and that although the Greeks, who were accustomed to the cultivation of the olive tree in their own country, tried to grow it in the most likely localities in Egypt (the Fayûm and the neighbourhood of Alexandria), it never really flourished and from an oil-producing point of view it has always been a failure.⁴

The evidence from the tombs for the cultivation of the olive tree in Egypt is very scanty and does not carry it farther back than the Eighteenth Dynasty, the period when Keimer states that it was probably introduced into the country.⁵ The principal discoveries that can be traced are (a) in the tomb of Tut-

¹ G. Bonaparte, *Journ. Khedivial Agricultural Society*, III (1901), pp. 14-19.

² P. E. Newberry, *Appendix III*, in *The Tomb of Tut-ankh-Amen*, II, Howard Carter, p. 195.

³ Sir Armand Ruffer, *Food in Egypt*, in *Mém. de l'Inst. d'Égypt*, I (1919), p. 81.

⁴ The reason for this is probably primarily the scanty rainfall on the northern coast of Egypt as compared with that in the other countries named, even as compared with Tunis and Algeria, where there are mountains near the coast that precipitate the rain. A secondary reason may possibly be the salt that accumulates in the soil of Egypt on account of the absence of rainfall.

⁵ L. Keimer, (a) *Die Gartenpflanzen im Alten Ägypten*, p. 29 ; (b) in *Bull. de l'Inst. franc. d'arch. orientale*, xxxi (1931), p. 133.

ankhamûn, where there was a large funerary bouquet of persea, which contained a few very small olive twigs¹ and three wreaths partly composed of olive leaves²; (b) in the Cairo Museum there is a small twig with leaves of the olive tree marked as having been found by Schiaparelli at Thebes and dated to the period Twentieth to Twenty-sixth Dynasty; (c) there is also in the same museum a similar twig stated to have been found by Maspero at Gebelein and not to be earlier than the Ptolemaic period; (d) Braun refers³ to olive twigs and leaves (undated) in the Berlin Museum and to funeral wreaths of olive leaves (undated) in the Leyden Museum and (e) Newberry identified two olive stones from the Ptolemaic cemetery at Hawara.⁴

Radish Oil

This oil was obtained from the seeds of the radish (*Raphanus sativus*) and Pliny states⁵ that the radish was held in high esteem in Egypt on account of the large amount of oil that was extracted from it. Although the radish is still grown plentifully in the country, the oil is no longer prepared.

Safflower Oil

Safflower oil is the oil expressed from the seeds of *Carthamus tinctorius* or false saffron, which is cultivated in Egypt at the present day chiefly for the sake of the oil, which is an agreeable, bland oil extensively used for salads and cooking.

Pliny mentions the safflower⁶ which he calls by its Greek name of *cnecos*, and states that it was esteemed by the Egyptians on account of the oil it produced. Elsewhere, however, he seems to confuse the safflower with the nettle,⁷ from which he says an oil (*cnidinum*, which apparently should be *cnecinum* and is *cnecinum* in another MS reading)⁸ was obtained.

¹ Howard Carter, *The Tomb of Tut-ankh-Amen*, II, p. 33.

² P. E. Newberry, in *Appendix III*, in *The Tomb of Tut-ankh-Amen*, II, Howard Carter, pp. 190-1.

³ A. Braun, *Journal of Botany*, 1879.

⁴ P. E. Newberry, in *Hawara, Biabmu and Arsinoe*, W. M. Flinders Petrie, p. 52.

⁵ XV, 7; XIX, 26.

⁶ XXI, 53.

⁷ XV, 7; XXII, 15.

⁸ B. P. Grenfell, *Revenue Laws of Ptolemy Philadelphus*, p. xxxvi.

The suggestion, already referred to,¹ that *cnecos* oil (*cnecinum*) was made from the seeds of the thistle or artichoke is without any support from the facts.

Sesame Oil

The sesame plant, which according to Muschler is probably of tropical African origin,² is grown plentifully in Egypt at the present day on account of the oil, which is expressed from the seeds. This oil is of a yellowish colour, clear and free from odour and has a bland agreeable taste. Pliny refers to Egyptian sesame oil.³

Uses of Oils and Fats

Oils and fats were employed in ancient Egypt for eating ; cooking and illumination ; for anointing both the living and the dead ; for libations ; as a base for perfumes ; as medicines and vehicles for medicines and doubtless for many other purposes.

In addition to the large local supply, oil was also imported from abroad to some extent from an early period and to an increasing extent later, thus in the Eighteenth Dynasty there are records of oil having been brought from Naharin,⁴ Retenu⁵ and Zahi,⁶ all in western Asia, and in the Twentieth Dynasty from Syria.⁷

Beeswax

The only wax used in ancient Egypt, so far as is known, was beeswax. This has already been briefly dealt with in connexion with mummification,⁸ but large quantities were employed for other purposes, for instance, as an adhesive (examples of its use for luting on the covers of alabaster vases and for other purposes occurred in the tomb of Tut-ankhamûn,⁹ and Spurrell found it used for fastening in place the flint teeth of sickles)¹⁰ ;

¹ See p. 271.

² R. Muschler, *A Manual Flora of Egypt*, pp. 884-5.

³ xv, 7.

⁴ J. H. Breasted, *op. cit.*, II, 482.

⁵ II, 473, 491, 509, 518.

⁶ II, 462, 510, 519.

⁷ IV, 233, 376.

⁸ See p. 234.

⁹ A. Lucas, *Appendix II*, pp. 167, 180, in *The Tomb of Tut-ankb-Amen*, II, Howard Carter.

¹⁰ F. C. J. Spurrell, in *Tell el Amarna*, W. M. Flinders Petrie, pp. 37, 38.

for coating painted surfaces¹; as a paint vehicle in the encaustic process of painting²; for permanently fixing the curls and plaits in wigs³; for making magical figures; in ship-building⁴; and at a very late date for covering the surface of writing tablets.

Eleven specimens of beeswax from mummies examined by the author had melting points ranging from 63° C. to 70° C.⁵ and five specimens from wigs varied from 60° C. to 63° C.,³ the melting point of modern beeswax being from about 60·5° C. to 64·25° C. These specimens, although light coloured and somewhat friable on the surface, had apparently not undergone any considerable change.

It does not seem to have been the custom to place beeswax in tombs and no record of it having been so found can be traced, but at El-Amârna a piece was found in a house.⁶

¹ See p. 294.

² See p. 295.

³ A. Lucas, *Ancient Egyptian Wigs*, in *Annales du Service*, xxx (1930), pp. 190-6.

⁴ M. Rostovtzeff, *A Large Estate in the Third Century B.C.*, p. 123.

⁵ A. Lucas, *Preservative Materials used by the Ancient Egyptians in Embalming*,

P. 53.

⁶ T. E. Peet and C. L. Woolley, *The City of Akhenaten*, I, p. 25.

CHAPTER X

PAINTING MATERIALS : WRITING MATERIALS : DYEING MATERIALS

PAINTING MATERIALS

Pigments

The freshness and brightness of the colours of the old Egyptian tomb paintings have often been commented upon, and it is sometimes assumed that the pigments employed were such as do not exist at the present day and even that their nature is unknown. This, however, is not so, as they have frequently been analysed and, with very few exceptions, they are either naturally occurring minerals, finely ground, or they have been made from mineral substances, to which fact is primarily due their excellent state of preservation.

The colours employed, taking them in alphabetical order, were, black, blue, brown, green, grey, pink, red, white and yellow, which may be separately considered.

Black

The black pigment was almost always carbon in some form, though possibly not always in the same form, as though generally it is in a very finely divided condition and consists of soot (probably scraped from cooking vessels), occasionally it is fairly coarse. Soot, however, if carelessly collected, or if collected from masonry or plaster surfaces, might be contaminated with particles of mineral matter that would give it a coarse texture.

The author has examined twelve different specimens of black pigment, one of the Fifth Dynasty, three of the Sixth Dynasty; seven of the Eighteenth Dynasty and one of the Twenty-third Dynasty, all of which were carbon and eleven of which were

fine soot, but one of which (Eighteenth Dynasty) was coarser than is usual with soot, and unfortunately in this particular case the amount of material available was too small for any detailed analysis.

Laurie found that a black pigment of the Nineteenth Dynasty was powdered charcoal¹: Spurrell identified a black pigment of the Twelfth Dynasty from Beni Hasan as pyrolusite,² a black ore of manganese that occurs plentifully in Sinai: the bone black reported by Beke³ needs confirmation before it can be accepted, as Beke states that the recognition was made 'without the aid of chemical analysis.' A blue-black pigment, not identified, but of which it is stated that it does 'not seem to be pounded charcoal,'⁴ is known from the predynastic period.

Blue

The earliest blue pigment that can be traced is, as is only to be expected, a naturally occurring mineral, namely azurite (chessylite), a blue carbonate of copper that is found native both in Sinai and in the eastern desert. This was identified by Spurrell from a shell used as a palette found at Medûm (Fourth Dynasty)⁵ and, according to the same authority, the blue colour employed for painting the mouth and eyebrows on the cloth that covered the face of a mummy of the Fifth Dynasty was also azurite,⁵ though he adds, 'It looks green from age and staining, which is an accident.' With respect to this same mummy, however, Petrie says,⁶ 'The eyes and eyebrows were painted on the outer wrapping with green,' and Elliot Smith states⁷ that 'the eyes were represented by green paint' and also⁷ that 'The pupils, edges of the eyelids and the eyebrows are painted with green malachite paste.'

¹ A. P. Laurie, *The Materials of the Painter's Craft*, pp. 26-7.

² F. C. J. Spurrell, *Notes on Egyptian Colours*, in *The Archaeological Journal*, LII, Second Series, II (1895), p. 229.

³ C. T. Beke, *Of the Colours of the Ancient Egyptians*, in *Trans. Royal Society of Literature of the U.K.* (1843), pp. 48-51.

⁴ J. E. Quibell and F. W. Green, *Hierakonpolis*, II, p. 21.

⁵ F. C. J. Spurrell, (a) *op. cit.*, p. 227; (b) in *Medûm* (W. M. Flinders Petrie), p. 29.

⁶ W. M. Flinders Petrie, *Medûm*, p. 18.

⁷ G. Elliot Smith, *Egyptian Mummies*, in *Journal of Egyptian Archaeology*, I (1914), pp. 192-3.

The principal blue pigment of ancient Egypt was an artificial frit that consisted of a crystalline compound of silica, copper and calcium (calcium-copper silicate). This was made by heating together silica, a copper compound (probably generally malachite), calcium carbonate and natron. Flinders Petrie shows that in at least one place the silica used was in the form of quartz pebbles,¹ that were employed on account of their practical freedom from iron compounds, which if present in more than traces would have produced a green instead of a blue colour. In the original description of this frit factory,¹ 'alkali' merely is referred to, without any statement whether it was potash or soda, there being no evidence on this point, but in a later account Petrie calls it potash,² though no proof is given that it was potash, and since soda occurs naturally in Egypt in the form of natron (which contains traces of potash as an impurity), whereas potash would have had to be made from plant ashes, it seems much more likely that soda was used and the few analyses of this frit that have been published in no case show more than a very small proportion, if any, of potash and in one instance a comparatively large proportion of soda. Vitruvius, too, states³ that the Egyptian blue frit (which he calls *cæruleum* and which he says was invented at Alexandria, though it was known more than 2,000 years before Alexandria was built) was made by fusing together sand, copper filings and natron (*nitri flore*). It will be noticed that Vitruvius makes no mention of calcium carbonate, which was an essential ingredient in the manufacture of the frit, but like the calcium carbonate required for making glass, this evidently was not recognized as such and, although it must have been added separately when quartz pebbles were used, this need not have been the case when sand was employed, as much of the Egyptian sand is a mixture of quartz and calcium carbonate. Theophrastus refers to a material that he calls *kyanos*,⁴ which he says was invented in Egypt, that was probably this blue frit, and Pliny mentions Egyptian *cæruleum*,⁵ which he calls a kind of sand, which was possibly also this frit, but the references to it are very obscure.

¹ W. M. Flinders Petrie, *Tell el Amarna*, p. 25.

² W. M. Flinders Petrie, *The Arts and Crafts of Ancient Egypt*, p. 117.

³ *De Architectura*, VII, XI, I.

⁴ *History of Stones*, XCVIII.

⁵ XXXIII, 57-8.

The composition of this frit has been investigated by many chemists beginning with Sir Humphry Davy in 1815,¹ but more especially by Dr. W. T. Russell,² who made specimens of it, and more recently by Laurie, McLintock and Miles,³ who repeated and extended Russell's work.

The date when this frit was first used is uncertain, but it has been found as early as the Fourth Dynasty by both Spurrell⁴ and Laurie,⁵ the former of whom examined specimens from the Fourth, Twelfth and Eighteenth Dynasties respectively and the latter from the Fourth and Eleventh Dynasties: Soule found it in the Fifth Dynasty tomb of Per-neb⁶ and the author has examined twenty-nine specimens of blue colour that proved to be frit⁷ (Fifth Dynasty, two; Sixth Dynasty, two; Thirteenth Dynasty, two; Eighteenth Dynasty, nineteen; Nineteenth Dynasty, two; Twentieth to Twenty-sixth Dynasty, two).

In addition to its use as a pigment the frit was carved into small objects, as examples of which may be mentioned a cylinder seal of the Sixth Dynasty⁸; a cylinder, also of the Sixth Dynasty⁹ and a small sphinx of the Nineteenth Dynasty.¹⁰

Laurie says of this frit that 'It was used not only in Egypt, but also in Rome in imperial times, as the universal blue for fresco-paintings,'¹¹ and that it 'disappeared from the artist's palette somewhere between the second and the seventh century.'¹² Specimens of this frit found in Italy may be seen in the Naples Museum.

¹ *Some Experiments and Observations on the Colours used in Painting by the Ancients*, in *Phil. Trans.*, cv (1815).

² W. T. Russell, *Egyptian Colours*, in *Medûm* (W. M. Flinders Petrie), pp. 44-8.

³ *Egyptian Blue*, in *Proc. Royal Society*, A 89 (1914), pp. 418-29.

⁴ F. C. J. Spurrell, (a) *op. cit.*, pp. 227, 228, 232; (b) in *Medûm*, pp. 28-9.

⁵ A. P. Laurie, (a) *op. cit.*, p. 24; (b) *Ancient Pigments and their Identification in Works of Art*, in *Archæologia*, LXIV (1913), p. 317.

⁶ C. R. Williams, *The Decoration of the Tomb of Per-neb*, p. 27, n. 34.

⁷ A small proportion of colourless (uncombined) quartz was found in every case.

⁸ S. R. K. Glanville, Book Review in *Journal of Egyptian Archaeology*, xiv (1928), p. 190.

⁹ C. R. Williams, *op. cit.*, p. 31.

¹⁰ Now in the Cairo Museum.

¹¹ A. P. Laurie, *The Materials of the Painter's Craft*, p. 24.

¹² A. P. Laurie, *The Painter's Methods and Materials*, p. 95.

It is sometimes stated that powdered lapis lazuli and even powdered turquoise were employed as pigments in ancient Egypt, but there is no evidence for the use of either and considerable probability that they were not employed. It is true that an excellent and permanent blue colour, ultramarine, may be obtained from lapis lazuli by a process of levigating the finely powdered material, but the yield is very low, being only about 2 per cent, and there is no proof that this was known until about the beginning of the eleventh century A.D. Much of the ultramarine used at the present day is an artificial product first made in the early nineteenth century. Lapis lazuli merely powdered gives a very poor bluish-grey colour. Turquoise, too, would also make a very poor pigment, and it would have been much too precious for use on the large scale required for tomb painting, even if it could have been obtained in sufficient quantity.

The use of a cobalt pigment was reported by Toch from the Fifth Dynasty tomb of Per-neb,¹ but the accuracy of this was questioned by the author many years ago, and it has since been shown by Soule that the blue colour in this tomb is a calcium-copper silicate and not a cobalt blue.²

Sometimes Egyptian blue pigments, permanent as they usually are, have undergone a change of colour, thus the trefoil marks on the cow couch from the tomb of Tut-ankhamûn, although now of a very dark brown, almost black,³ colour have manifestly been blue originally and still show a little blue underneath the black, and as the material is granular and gives the tests for copper, it may be a deteriorated blue frit. The background of the painting of the cylindrical alabaster 'cosmetic jar' with the recumbent figure of a lion on the lid, from the same tomb, has also been blue originally and was still slightly blue in places when first examined.³ It was not found possible to take any of this pigment for analysis without damaging the object and its nature was not determined. Also in some of the tombs, for example that of Amenophis II, the blue colour has darkened

¹ M. Toch, *The Pigments from the Tomb of Per-neb*, in *Journal of Ind. and Eng. Chemistry*, 1918, p. 118.

² C. R. Williams, *op. cit.*, p. 27, n. 34.

³ Since covered with melted paraffin wax and further darkened.

in places and has become black or almost black and this does not appear to be due to smoke, which is the usual cause of blackening in tombs.

At some period, the date of which is unknown, though it was probably very late, another blue frit, of a darker, brighter, more brilliant and more beautiful colour was apparently made or employed in Egypt, but is only known from a small bagful that was found some years ago in the Cairo Museum stores and of which neither the provenance nor the date could be traced. This is coloured, not by means of copper, as is the ordinary frit, but with an iron compound.¹

Brown

Certain brown pigments of the Fourth Dynasty examined by Spurrell were made by painting a red colour over a black, though generally the brown consisted of ochre, a natural oxide of iron.² A specimen of brown pigment used for painting a box of Eighteenth Dynasty date examined by the author proved to consist of oxide of iron and gypsum, but whether the mixture was natural or artificial it was impossible to determine, but natural mixtures of this nature are known. No record of any analysis of the brown colours on predynastic pottery can be traced, but they are undoubtedly natural oxide of iron. A good quality of brown ochre occurs in Dâkhla oasis.³

Green

It is generally accepted that the green pigment of the ancient Egyptians owes its colour to copper and two different materials were mainly employed, one being powdered malachite (a natural ore of copper that occurs both in Sinai and in the eastern desert), which was employed for painting round the eyes as early as the Badarian and earliest predynastic periods⁴ and the other was an artificial frit analogous to the blue frit already considered. A green colour of predynastic date is described as being 'bright green, granular in structure, probably pounded malachite'⁵: Spurrell records the use of malachite and malachite and gypsum

¹ For analysis, see p. 432.

² F. C. J. Spurrell, in *Medûm*, p. 29.

³ H. J. L. Beadnell, *Dakhla Oasis*, p. 100.

⁴ See p. 79.

⁵ J. E. Quibell and F. W. Green, *Hierakonpolis*, II, p. 21.

in tomb paintings of the Fourth Dynasty¹ and in Twelfth Dynasty tomb paintings he found both malachite and chrysocolla (another natural ore of copper), the former predominating²: Soule identified the green colour from the Fifth Dynasty tomb of Per-neb as malachite³: the author has found malachite in a Fifth Dynasty tomb painting at Giza and the green on two boats from the tomb of Tut-ankhamûn was not frit and may have been malachite, but the green colour in a Sixth Dynasty tomb was frit, as also were six specimens from the Eighteenth Dynasty, one from the Nineteenth Dynasty and one from the period Twentieth to the Twenty-sixth Dynasty: a green coloured plaster from a stick of Eighteenth Dynasty date was found to owe its colour to a mixture of blue frit and a yellow colour that was not identified, but which was not yellow ochre and which was probably an organic material. Spurrell, who examined the pigments from certain Twelfth Dynasty tombs at El-Bersha for Newberry, stated that the green was chrysocolla in some instances and a mixture of blue frit and yellow ochre in others,⁴ and Layard states⁵ that the Egyptian green was 'a mixture of yellow ochre with the vitreous blue.'

Grey

The ancient Egyptian grey pigment was generally a mixture of black and white, in the Fifth Dynasty tomb of Per-neb being a mixture of gypsum and charcoal,⁶ and Spurrell found a grey pigment from the Fourth Dynasty to consist of a mixture of a pale yellowish earth and lamp black.¹

Pink

A pink colour was not uncommon in the New Kingdom, thus it is recorded from the tomb of Amenemhet (Eighteenth Dynasty),⁷ and the author has noticed it in the tomb of Nefertari

¹ F. C. J. Spurrell, in *Medûm*, p. 29.

² F. C. J. Spurrell, in *The Arch. Journal*, LII, Second Series, II (1895), p. 227.

³ C. R. Williams, *op. cit.*, p. 26, n. 24.

⁴ Letter dated March 26th, 1892, from Mr. Spurrell to Professor Newberry who has kindly allowed the author to make use of it.

⁵ A. H. Layard, *Nineveh*, II (1854), p. 310.

⁶ C. R. Williams, *op. cit.*, p. 25, n. 19.

⁷ N. de G. Davies and A. H. Gardiner, *The Tomb of Amenemhet*, p. 98.

(Nineteenth Dynasty) where it was used to a considerable extent. Glanville states ¹ that 'in the New Kingdom pink colour was regularly obtained by simply mixing red and white,' but no reference is given to any analysis. The pink, however, at this date was certainly due to oxide of iron. A pink colour from a tomb painting of the Græco-Roman period was identified by Russell as consisting of madder (obtained from the roots of the madder plant, a native of Greece, often called Turkey red) on a base of gypsum ² and a similar shade of colour, probably of the same composition, is sometimes present on coffins of this period. It seems likely that this madder colour was introduced into Egypt by either the Greeks or the Romans, as the former probably knew it and the latter certainly did, since there are specimens of it in the Naples Museum.

Red

The principal red pigment of ancient Egypt, and the only one until a very late date, was red ochre, a natural oxide of iron that occurs plentifully in the country. This ochre is sometimes called hæmatite and, although it is an amorphous earthy variety of hæmatite, it would be better in the author's opinion to restrict the term hæmatite in Egyptology to the black metallic-looking mineral employed for carving into beads, *kohl* sticks, scarabs and other small objects.

A red pigment of predynastic date identified as red ochre is known ³ and the reddish colours on the predynastic pottery are manifestly red ochre, although no analyses of them can be traced: Spurrell found red ochre (which he calls red hæmatite) and also red ochreous clays mixed with fibrous gypsum from the Fourth Dynasty ⁴ and red ochre (which he calls ground hæmatite) and burnt yellow ochre from both the Twelfth Dynasty and the Eighteenth Dynasty ⁵: Russell found red ochre from

¹ S. R. K. Glanville, Book Review in *Journal of Egyptian Archaeology*, XIV (1928), p. 190.

² W. T. Russell, in *Medûm*, p. 47.

³ J. E. Quibell and F. W. Green, *op. cit.*, p. 21.

⁴ F. C. J. Spurrell, in *Medûm*, pp. 28-9.

⁵ F. C. J. Spurrell, in *The Arch. Journal*, LII, Second Series, II (1895), pp. 227, 231.

the Twelfth and also from the Eighteenth or Nineteenth Dynasty¹ and the author has identified both red ochre and red ochre mixed with gypsum from the Sixth Dynasty; ten specimens of red ochre and one of red ochre mixed with gypsum from the Eighteenth Dynasty; one specimen of red ochre from the Nineteenth Dynasty and two from the period Twentieth to Twenty-sixth Dynasty. The Egyptian earths, *sinopis* and *rubrica*, referred to by Pliny as being employed by the Romans for pigment purposes,² were almost certainly red ochre. Vitruvius mentions red ochre from Egypt.³

The usual manner of making red ochre in Europe before the modern methods of manufacture from various by-products were introduced was by calcining yellow ochre, and though in any locality in Egypt in which yellow, but not red, ochre occurred the latter might have been made from the former by heating it; this was certainly not usual, the red ochre used being generally the material as found naturally, and what evidence Spurrell had for calling some of the red ochre he examined 'burnt yellow ochre' is not stated, and it is impossible as a rule to distinguish one from the other, especially when dealing with a very small quantity of pigment scraped from an ancient object. A good quality ochre of a deep-red shade is found in several localities in Egypt, of which two may be mentioned, one near Aswan,⁴ where it was worked anciently, and the other in the oases of the western desert.^{5, 6} A number of instances are recorded in Egypt in which yellow ochre on a tomb wall has been changed to red by the heat produced from a fire in the tomb.

A red pigment of Græco-Roman date from Hawara was identified by Russell as red lead⁷ (a red oxide of lead that occurs naturally), one of the few instances which has been reported from Egypt, though it was well known to the Romans of Pliny's day and was probably introduced by them into Egypt.

¹ W. T. Russell, in *Medûm*, pp. 44-8. ² XXXV, 13-15. ³ VII, VII, 2.

⁴ L. Nassim, *Minerals of Economic Interest in the Deserts of Egypt*, in *Report of Congrès Intern. de Géog. Le Caire, Avril, 1925*, III (1926), p. 164.

⁵ W. F. Hume, *Explan. Notes to Accompany Geol. Map of Egypt*, p. 38.

⁶ H. J. L. Beadnell, *Dakbla Oasis*, pp. 99-100.

⁷ W. T. Russell, in *Medûm*, pp. 44-8.

White

The use of white pigment for mural painting is known from the predynastic period,¹ but the nature of the material then employed, and also of that used on the predynastic pottery, has not been determined, though it must have been either calcium carbonate (whiting, chalk) or calcium sulphate (gypsum), as these were the only two white pigments known. Spurrell found gypsum from the Fourth Dynasty² and from the Eighteenth Dynasty,³ but calcium carbonate from the Twelfth Dynasty at El-Bersha⁴: Russell found gypsum from the Græco-Roman period at Hawara⁵: the author has identified calcium carbonate from the Fifth Dynasty; calcium sulphate from the Sixth Dynasty; twelve specimens of calcium carbonate and two of calcium sulphate from the Eighteenth Dynasty and calcium carbonate from the Twenty-third Dynasty. Both calcium carbonate and calcium sulphate occur plentifully in the country.

Yellow

Two different yellow pigments were employed by the ancient Egyptians, one being yellow ochre, which occurs plentifully in the country and the colouring matter of which is due to hydrated oxide of iron, and the other being orpiment, a natural sulphide of arsenic. Yellow ochre was used in predynastic times⁶: Spurrell found yellow ochre from the Fourth,⁷ Twelfth⁸ and Eighteenth Dynasties⁸ respectively and orpiment from the Eighteenth Dynasty⁸: Mackay refers to the use of orpiment in certain tombs in the Theban necropolis⁹: the author found

¹ J. E. Quibell and F. W. Green, *op. cit.*, p. 21.

² F. C. J. Spurrell, in *Medûm*, p. 28.

³ F. C. J. Spurrell, in *The Arch. Journal*, LII, Second Series, II (1895), p. 232.

⁴ Letter dated March 26th, 1892, from Mr. Spurrell to Professor Newberry, who has kindly allowed the author to make use of it.

⁵ W. H. Russell, in *Medûm*, pp. 44-48.

⁶ J. E. Quibell and F. W. Green, *op. cit.*, p. 21.

⁷ F. C. J. Spurrell, in *Medûm*, p. 28.

⁸ F. C. J. Spurrell, in *The Arch. Journal*, LII, Second Series, II (1895), pp. 227, 231-2.

⁹ E. Mackay, *On the Use of Beeswax and Resin as Varnishes in Theban Tombs*, in *Ancient Egypt*, 1920, p. 37.

that three specimens of yellow pigment from the Eighteenth Dynasty were yellow ochre and eight were orpiment : one specimen from the Nineteenth Dynasty was ochre and two from the period Twentieth to Twenty-sixth Dynasty were also ochre : Russell reports yellow ochre from the Græco-Roman period.¹ Yellow ochre occurs near Cairo ² and in the Oases of the western desert.³

At one time orpiment, originally the naturally occurring mineral and afterwards an artificial product, was largely employed as a pigment in Europe, but its use was discontinued on account of the very poisonous nature of the artificial substance. The natural mineral, however, is not poisonous and it was this that was used in ancient Egypt : in addition to its identification as a pigment on various objects and mural paintings a small quantity of the mineral in its natural state was found in a linen bag in the tomb of Tut-ankhamûn and was examined by the author.⁴ As orpiment, so far as is known, does not occur in Egypt, it must have been imported and probably from Persia, though it also occurs in Armenia and in Asia Minor : its use in Egypt cannot be traced earlier than the Eighteenth Dynasty.

Paint Brushes

These have already been described in connexion with Fibres.⁵

Paint Vehicles

Much discussion has taken place respecting the nature of the paint vehicles employed in ancient Egypt. The colours used, which have just been described, were ordinary well known materials, but in what state were they applied ?

In modern painting practice there are two principal vehicles, one being a mixture of a fixed oil that dries (i.e. oxidizes) on exposure to the air (usually linseed oil, though formerly sometimes poppy seed oil or walnut oil) and a volatile oil (generally

¹ W. T. Russell, in *Medûm*, pp. 44-8.

² L. Nassim, *op. cit.*, p. 165.

³ W. F. Hume, *op. cit.*, p. 38.

⁴ A. Lucas, *Appendix II*, p. 177, in *The Tomb of Tut-ankh-Amen*, III, Howard Carter.

⁵ See p. 132.

oil of turpentine, though recently sometimes a light petroleum spirit) and the other being a mixture of water and some adhesive, often size (gelatine or glue) or gum. Paints of the first kind are oil paints and those of the second kind are tempera paints (distempers).

It is manifest on examination that the ancient Egyptian paintings are not oil paintings, but tempera paintings.¹ Although linseed oil was probably known in Egypt from a very early date and although poppy seed oil is mentioned by Dioscorides² and walnut oil by Pliny,³ none of these was used for painting until late, probably not until about the sixth century A.D. or after. Oil of turpentine, too, although certainly known in Pliny's day, since he describes a method of making the crude product,⁴ and also probably to the Greeks at a somewhat earlier period,⁵ was not employed for painting at that time and petroleum spirit is entirely a modern product.

The ancient Egyptian painting being tempera painting, it follows that some adhesive was used in its production, in the same manner as size and gum are employed to-day, since although pigments, such as soot and red and yellow ochres, will adhere to plaster and stone to some extent if applied dry, and although the ochres will adhere still better if wetted, others of the ancient pigments, such as azurite, malachite and the blue and green frits, will not adhere without some binding material. The possible and likely materials to have been used seem to be limited to size (gelatine, glue); gum and albumin (white of egg).

Spurrell found gelatine or size from the Fourth Dynasty^{6, 7}; albumin (thought to be egg albumin) from the Twelfth Dynasty⁸

¹ Excluding painting executed with a wax medium which will be described separately; see pp. 294-5.

² Referred to by A. P. Laurie, in *The Materials of the Painter's Craft*, p. 65.

³ xv, 7; xxiii, 45.

⁴ xv, 7.

⁵ A. Lucas, 'Cedar'-Tree Products employed in Mummification, in *Journal of Egyptian Archaeology*, xvii (1931), p. 16.

⁶ F. C. J. Spurrell, in *Medum*, p. 50.

⁷ Spurrell also thought he found resin (probably mastic); but even if present, resin could not possibly have been employed as an adhesive with water.

⁸ F. C. J. Spurrell, in *The Arch. Journal*, LII, Second Series, II (1895), pp. 226, 229, 230, 238, 239.

and both albumin and gum (thought to be gum acacia) from the Eighteenth Dynasty¹: Toch² thought he found evidence of glue or gelatine, though not of albumin in the Fifth Dynasty tomb of Per-neb, and Laurie found gum in a pigment of the Nineteenth Dynasty³: although the author has examined a very large number of pigments from objects and mural paintings, these have all been in too small a quantity for any satisfactory determination to be made of the adhesive used.

In this connexion it may be pointed out, what seems sometimes to be forgotten, that the presence of gelatine or glue in a pigment does not necessarily mean that this material had been employed as a binder in the paint, since it may have been used in the same manner as modern size, namely, to fill up the pores in the plaster, stone, or other painting ground before the paint was applied.

It may be mentioned, too, that there are very considerable difficulties in identifying with certainty such materials as gelatine, glue, gum or albumin when present only in minute proportions in very small specimens of pigments that have been exposed for hundreds or even thousands of years and in which, therefore, the binding material, particularly if albumin, may have undergone chemical change, especially as there is no specific test for any of the materials in question.

One adhesive used in Egypt for painting and for coating paintings, about which there is no uncertainty, is beeswax. Its use for mural paintings seems to have first been pointed out by Mackay,⁴ who mentions eight Eighteenth Dynasty tombs in the Theban necropolis in which there is evidence of wax, these ranging in date from the time of Amenophis I to that of Amenophis II. Although in some instances the wax is intimately mixed with the pigment, as though used as a binder, in other instances it has apparently been applied to the surface

¹ F. C. J. Spurrell, in *The Arch. Journal*, LII, Second Series, II (1895), pp. 226, 229, 230, 238, 239.

² M. Toch, *The Pigments from the Tomb of Perneb*, in *Journal of Ind. and Eng. Chemistry*, 1918, p. 118.

³ A. P. Laurie, (a) *The Materials of the Painter's Craft*, p. 22; (b) *The Painter's Methods and Materials*, pp. 17, 172.

⁴ E. Mackay, *On the Use of Beeswax and Resin as Varnishes in Theban Tombs*, in *Ancient Egypt*, 1920, pp. 35-8.

of the finished painting as a protective coating. Petrie mentions the use of wax¹ 'as a filling of the hieroglyphs on the red granite coffin of Ramessu III in the Louvre; also in incised figures on the wooden coffins.' He also states¹ that 'The use of wax over colours was noted on the late sarcophagus of Ankhruî at Hawara.' The use of wax in the Eighteenth Dynasty was also noticed by Spurrell, who found it at El-Amârna,² and by de Garis Davies, who says with respect to the mural paintings in the tomb of Puyemrê, 'A film of wax seems present on many figures, but whether this was a medium used with the colours or was applied afterwards is not clear.'³ The author found one instance of the use of wax in the tomb of Tut-ankhamûn, where there was a wooden box having an incised inscription filled with yellow pigment (orpiment) that was coated with beeswax, which had deteriorated, causing the pigment to appear almost white.⁴ The use of beeswax as a medium for painting was well known to the Romans and is described by Pliny,⁵ who terms the method 'encaustic painting,' and about one hundred portraits in this technique of Roman age (second and third centuries A.D.) mostly on wood, but a few on canvas, used to place over the faces of mummies, were found by Petrie in the Fayûm province of Egypt.⁶ A bowl of late date, probably Coptic, with polychrome designs in the encaustic technique is described by Edgar, who states that 'The colours have been mixed with wax and put on with the brush.'⁷

Painting Grounds

The principal materials used in ancient Egypt for painting upon, taking them in alphabetical order, were canvas, papyrus, plaster, pottery, stone and wood. Of these, the earliest to be used was pottery, and this painted pottery will be dealt with separately.⁸

¹ W. M. Flinders Petrie, Note to Mackay's article, *Ancient Egypt*, p. 38.

² F. C. J. Spurrell, in *The Arch. Journal*, LII (Second Series, II (1895), p. 239.

³ N. de G. Davies, *The Tomb of Puyemrê at Thebes*, I, p. 11.

⁴ A. Lucas, in *The Tomb of Tut-ankh-Amen*, Howard Carter, II, p. 180.

⁵ xxxv, 31, 39, 41.

⁶ W. M. Flinders Petrie, *Roman Portraits and Memphis (IV)*.

⁷ C. C. Edgar, *Greek Vases*, in *Cat. Gén. du Musée du Caire*, No. 26347, p. 81.

⁸ See p. 333.

The next material in chronological order was plaster, of which several kinds were employed, namely, clay, gypsum and whiting (chalk). The earliest mural painting known in Egypt, which is of predynastic date, is executed directly on clay plaster¹ and this was also used as a painting ground at later periods, particularly in the Eighteenth Dynasty at El-Amârna, where, both in the palaces of the king and also in private houses, the most beautiful painting was done directly on the clay plaster with which the walls of the sun-dried bricks were faced. The usual Egyptian plaster for painting upon, however, was either gypsum or whiting, the former being largely employed for mural paintings and the latter being chiefly used as a covering for wooden objects, such as coffins, boxes and stelæ, which were subsequently to be painted.

Gypsum plaster has already been considered²: a comparatively coarse quality was used for covering up faults and irregularities in the stone wall that was to be sculptured or painted or both and on this was laid a finer quality of similar plaster in order to obtain a smooth surface, this latter being often coated with whitewash to fill up the pores before painting.

Whiting plaster has also been briefly mentioned,³ but may further be considered. By Egyptologists, this plaster, which is a mixture of whiting (chalk) and glue, is generally called 'gesso,' but the term is ambiguous and is sometimes used for gypsum plaster or for gypsum and glue plaster. In mediæval Italy and Spain, gypsum mixed with glue water (size) was employed by artists to produce a ground for painting upon, which was termed gesso, an Italianized form of the Latin word *gypsum*, which is derived from the Greek *gypsos*. The term gesso in Italian, however, may mean any kind of gypsum or gypsum plaster. According to Cennino Cennini (fifteenth century)⁴ gesso was of two kinds, *gesso grosso*, which was unslaked gypsum, and *gesso sottile*, which was slaked gypsum, both being used with glue. Theophilus, writing about the eleventh or twelfth century,⁵ refers to the use of both slaked lime and glue and whiting and glue

¹ J. E. Quibell and F. W. Green, *op. cit.*, II, p. 21.

² See p. 76.

³ See p. 75.

⁴ A. P. Laurie, *The Materials of the Painter's Craft*, pp. 189-92.

⁵ A. P. Laurie, pp. 157, 159-60.

for coating skins as a ground for painting upon and Church states¹ that 'The ordinary ground for Italian and Spanish tempera-paintings consisted either of whitening and size or of burnt gypsum . . . mixed with size.' This use of two different materials for the same purpose and the application of the same name to both is very confusing. Even *The New English Dictionary* gives the meaning of the Greek word *gypsos* as 'chalk, gypsum' as though these were synonymous, whereas they are two entirely different materials, and Church writes,² 'Gesso, made of plaster of Paris and size, or of whitening and size . . .' An outstanding example of painting on whitening plaster is the casket found in the tomb of Tut-ankhamûn, which is a very ordinary wooden box coated on the outside with this plaster, on the surface of which, exquisitely painted in colours, are miniature battle and hunting scenes.³

Stone was often painted or colour-washed, not only the stone walls of tombs and temples, but also stone statues, statuettes, sarcophagi and other objects, especially, though not exclusively, those of limestone and sandstone, other stones, however, including granite, alabaster, quartzite and schist⁴ being also sometimes painted. Before painting, a thin coat of whitewash was often, though not always, applied to the stone,⁵ thus with respect to the painting of the walls of the temple of Medinet Habu, Nelson says, 'As the sandstone was too rough to take paint satisfactorily, a thin wash was applied to the stone before the colour was laid on.'⁶

The use of papyrus for painting upon is so well known that no description is necessary.

Canvas as a painting ground has already been referred to in connexion with the portraits of Roman date found by Petrie in the Fayûm,⁷ some few of which are on this material. Another example of painted canvas is the so-called 'painted handkerchief' from Deir el-Madîna, now in the Cairo Museum

¹ Sir A. H. Church, *The Chemistry of Paints and Painting*, 1915, pp. 22-3.

² Sir A. H. Church, *op. cit.*, p. 32.

³ Howard Carter and A. C. Mace, *The Tomb of Tut-ankh-Amen*, I, pp. 110, 111; Pls. XXI, L-LIV.

⁴ G. A. Reisner, *Mycerinus*, p. 127.

⁵ See p. 76.

⁶ H. H. Nelson and Others, *Medinet Habu*, I, p. 7.

⁷ See p. 295.

(No. J, 54885), and painted linen shrouds are well known from the Greek and Roman periods.

Wood was usually covered with plaster before being used as a painting-ground, though this was not always so, the paint sometimes being put directly on the wood, especially in the case of furniture and boxes, which were often painted in one colour only, usually red, white or brownish-yellow.

Since the greater number of the ancient Egyptian paintings are on the walls of tombs and temples and since fresco painting is a common form of mural decoration, as for example, the palace paintings at Knossos in Crete and those at Tiryns on the mainland opposite; the paintings at Herculaneum and Pompeii respectively and many of the mediæval wall paintings in Italy, the Egyptian mural paintings are often called frescoes, which are paintings executed on a damp surface made caustic with lime and without any other medium than water, which the Egyptian paintings never are. With respect to the painted pavement found by Petrie at El-Amârna, the discoverer states¹ that 'the colours were laid on while the plaster was wet and even while it could still be moved by the brush,' which suggests a true fresco and which has been interpreted in that sense,² but fortunately the author has been able to analyse a specimen of this plaster kindly supplied by Mr. S. R. K. Glanville, which proved to be gypsum containing a large proportion of calcium carbonate (a very common impurity in Egyptian gypsum) and particles of unburnt fuel. Professor Laurie has informed the author that he has found by practical experience that gypsum plaster, if painted upon before it is thoroughly dry, will show brush marks.

One interesting fact that may be mentioned in connexion with painting is that in some instances pigments have corroded the ground on which they were painted, thus Mr. and Mrs. de Garis Davies state that some of the colours 'eat away' the plaster, leaving depressions,³ and Mace and Winlock describe a painted canopic box where the pigment, probably blue, had

¹ W. M. Flinders Petrie, *Tell el Amarna*, p. 12.

² S. R. K. Glanville, *Book Review*, in *Journal of Egyptian Archaeology*, XIV (1828), pp. 189-90.

³ Kindly communicated verbally.

corroded the wood in such a manner that what were originally painted inscriptions are now merely a series of holes in the wood, looking almost as though they had been burned.¹ This is attributed to the chemical composition of the pigment; but it seems much more likely that in all such cases the fault lies not with the pigment but with the vehicle which was either acid when used, or which became acid subsequently, owing to chemical decomposition having taken place.

Varnish

The ancient Egyptian varnish is of two kinds, one originally colourless or practically colourless, though now brown, yellow or red and the other originally black and still black, both of which may now separately be described.

The colourless varnish was employed for covering mural paintings, wooden coffins, wooden canopic boxes, wooden stelæ and other objects.

The use of varnish in certain tombs in the Theban necropolis is mentioned by Mackay,² de Garis Davies,^{3, 4} and Davies and Gardiner,⁵ Mackay giving a list of ten late Eighteenth Dynasty tombs in which it has been used. In addition to its employment in the usual manner as a coating over the paintings, Mackay suggests that in some instances the pigment and varnish may have been mixed and applied together. Sometimes the varnish covers the whole surface of a wall, as for example in the tomb of Kenamûn,⁶ but more usually only certain colours, generally red and yellow, are varnished. This selective treatment may also be seen in the temple of Hatshepsût at El-Deir el-Bahari.

As examples of the use of varnish other than for mural paintings may be mentioned (a) the wooden box with the painted miniature hunting and battle scenes from the tomb of Tut-

¹ A. C. Mace and H. E. Winlock, *The Tomb of Senebtisi at Lisht*, p. 32; Pl. VIII; and verbal statement by Mr. Mace.

² E. Mackay, *op. cit.*, pp. 36-7.

³ N. de G. Davies, *The Tomb of Nefer-Hotep at Thebes*, I, pp. 12, 59, 63.

⁴ N. de G. Davies, *The Tomb of Puyemrê at Thebes*, p. 11.

⁵ N. de G. Davies and A. H. Gardiner, *The Tomb of Huy*, pp. 2, 7, 22.

⁶ N. de G. Davies, (a) *The Tomb of Nakht at Thebes*, p. 57, n. 4; (b) *The Tomb of Ken-Amûn at Thebes*, I, p. 60.

ankhamûn, which is covered with a thin uniform coat of varnish, originally colourless, but now yellow¹; (b) various dummy wooden vases of the Eighteenth Dynasty, including two from the tomb of Yuya and Thuyu²; (c) especially the highly decorated wooden coffins and canopic boxes of the Twentieth Dynasty to about the Twenty-sixth Dynasty, which are usually varnished, the varnish often having been badly applied and put on thickly in some places and thinly in others, and (d) a small oval painted box of Roman date from the Fayûm described by Wainwright,³ who states that 'The whole has been given a coat of varnish, which has now turned black with age.' As varnish at this date is otherwise unknown the coating was examined by the author and was found to be soluble in alcohol and to exhibit all the characteristics of a resin varnish. A similar box of about the same date found by Petrie at Hawara is stated by him to be 'coated with glue.'⁴ As the coating was scaling off Petrie treated it with paraffin wax in order to preserve it, which unfortunately prevents any simple chemical examination.

No certain use of this varnish can be traced before the late Eighteenth Dynasty and only one instance of its use after the Twenty-sixth Dynasty, namely, that on the box of Roman date just described, and it appears to have been practically unknown in both Ptolemaic and Roman times. Daressy, writing of certain painted wooden coffins, states⁵ that the custom of varnishing them began in the Twentieth Dynasty and that it diminished and was lost a short time after the Twenty-second Dynasty.

There cannot be any doubt that this varnish, which is sometimes brown, though generally yellow where the coating is thin and orange-red where the coating is thick, was originally

¹ This box has now been treated with melted paraffin wax in order to preserve it.

² J. E. Quibell, *The Tomb of Yuaa and Thuiu*, in *Cat. Gén. du Musée du Caire*, Nos. 51075 and 51083, pp. 45-6.

³ G. A. Wainwright, *A Painted Box from Kom Washim*, in *Annales du Service*, xxv (1925), p. 97.

⁴ W. M. Flinders Petrie, *Hawara, Biahmu and Arsinoe*, p. 12; Pl. XIX (25).

⁵ G. Daressy, *Cercueils des cachettes royales*, in *Cat. Gén. du Musée du Caire*, Preface, p. iii.

colourless, or practically so, since there are a number of instances where a white painted surface, which is partly varnished and partly unvarnished, is now yellow or red in the former case, but remains white in the latter case, and the edges of the varnished portions are so very irregular and unsightly that this cannot have been the original appearance and it can only be explained on the assumption that when the varnish was applied it was colourless and did not show, or, as aptly expressed by de Garis Davies,¹ 'The original transparency of the varnish is proved by the carelessness with which it was applied.'

Laurie states² that 'The reddish colour is very likely due to the introduction of a red like dragon's-blood,' but there is no evidence whatever that the red is original and a practical certainty that it is adventitious.

Only very few analyses of this varnish can be traced, namely, one by Laurie,³ who states that his specimen (Nineteenth Dynasty) was soluble in alcohol and that it did not agree in its properties with pine resin, mastic or sandarach: one (undated) by Crow,⁴ which was soluble in alcohol, and ether, but insoluble in turpentine and petroleum spirit, and a number by the author (four Eighteenth Dynasty; one Twenty-first Dynasty; one of the period Twentieth Dynasty to Twenty-sixth Dynasty and several undated), which were all very similar in character and soluble in alcohol (both ethylic and amylic); slightly soluble in acetone and chloroform; insoluble or slightly soluble in ether and insoluble in turpentine, petroleum spirit and benzol. The ash in all cases was alkaline to phenolphthalein. The varnish is manifestly some kind of resin, but too little work has been done on the subject for any definite statement to be made respecting the nature of the resin, though as stated elsewhere,⁵ the solubility and non-solubility in the various solvents, especially the insolubility in turpentine (in which most resins are soluble) are suggestive of shellac, which is a product

¹ N. de G. Davies, *The Tomb of Puyemrê at Thebes*, p. 11.

² A. P. Laurie, *The Materials of the Painter's Craft*, p. 31.

³ A. P. Laurie, *op. cit.*, pp. 27-31.

⁴ J. K. Crow, *Report on Samples of Colours scraped from the Monuments*, in *Annales du Service*, IV (1903), pp. 242-3.

⁵ A. Lucas, *Annales du Service*, IX (1908), p. 7.

of the lac insect, parasitic on certain trees that grow in Ceylon and farther India. That it is shellac, however, seems improbable, chiefly on account of the dark colour of natural shellac, whereas the Egyptian varnish was originally practically colourless and even now is never so dark as the shellac obtainable anciently, the modern methods of bleaching shellac being then unknown. It should not be forgotten, however, that the solubility of a material often decreases with age and exposure, for example that of colophony in petroleum spirit ¹ and, therefore, insolubility in a particular solvent may not be an original, but an acquired characteristic.

Black Varnish

The black varnish was used on wood, possibly sometimes to simulate ebony or sometimes because a black colour was required for certain funerary objects. It is found, for example, on the wooden sarcophagi, the wooden canopic boxes and the food boxes of Yuya and Thuyu, on a number of objects from the tomb of Tut-ankhamûn (two large wooden statues, numerous shrine-shaped boxes, the bases of three large couches, steering paddles for boats, certain human and animal figures and other objects), on a number of broken objects from the tomb of Horemhab (large statues, human and animal figures and parts of couches) and on certain late (probably Persian or Ptolemaic) coffins of cats and possibly of other animals. The varnish on one cat's (and cat-shaped) coffin in the Cairo Museum that has been examined is very glossy and similar in composition to the black varnish from the Eighteenth Dynasty.

So far as can be ascertained this black varnish was not employed before the late Eighteenth Dynasty, any black coating on wooden funerary objects of earlier date, for example, that on three sarcophagi from El Qurna in the Cairo Museum dated to the Thirteenth or Fourteenth Dynasty (which has not been analysed, but which is mat and not glossy) is probably black paint and not varnish, and a black varnish-like coating on some copper funerary vases of Middle Kingdom date examined by the author proved to be a nitrogenous adhesive, probably either glue or albumin (white of egg) coloured with carbon. As already men-

¹ K. Dieterich, *The Analysis of Resins* (1920), pp. 161, 166.

tioned this black varnish was in use as late as about Ptolemaic times.

Though often called bitumen or pitch, this varnish is neither, nor does it contain bitumen or pitch, but it consists of a comparatively low melting point resin, largely soluble in alcohol (from 51.6 to 90.5 per cent in the specimens tested) and acetone; insoluble or practically insoluble in turpentine, petroleum spirit, carbon disulphide, ether and benzol; soluble in pyridine and saponifiable with caustic soda. The specimens tested all gave off ammoniacal vapours when heated with quick lime, which indicates nitrogenous organic matter, but this may have been glue used as a sizeing material on the wood before varnishing.

Since the varnished objects were originally and intentionally black, the varnish cannot have blackened with age, as resins sometimes do, but must have been a naturally black resin. A few such resins are known, thus there is a black dammar resin from *Canarium strictum*, which grows in western and southern India and which would be a suitable material for making black varnish. Naturally black varnishes that require no preparation are also known, such as the resin from *Rhus vernicifera* (Japan and China); the resin from *Melanorrhæa usitata* (Cochin-China and Cambodia); the resin from a species of *Melanorrhæa* (China) and the resin from *Melanorrhæa laccifera* (Indo-China), all of which are greyish-white viscous liquids when fresh and on exposure in thin films they dry to a hard black lustrous surface and are used as lacquers, and it seems probable that something of the kind may have been employed in Egypt.

Mode of Use

Before leaving the subject of varnish it becomes necessary to say something about the manner in which it was applied. The base of the old Egyptian varnishes, as of modern varnishes (excepting the very recent cellulose varnishes), is resin, but before resin can be applied as a thin coating it must be in a more or less liquid condition and the present day varnishes consist of a particular kind of resin dissolved in a 'drying' oil (generally linseed oil), turpentine or alcohol. Had a drying oil been employed anciently there would be abundant evidence, but

there is no such evidence, and neither turpentine nor alcohol were known until a very late date; moreover the ancient varnish is insoluble in turpentine. Petrie suggests¹ that strong wine may have been used as a solvent, but the author has tried to make a varnish from old Egyptian resins and also from modern varnish resins (mastic, sandarach and shellac) using the strongest white wine obtainable,² but without success, and the ancient varnish is not soluble in wine. The alternatives, therefore, seem to be, either a resin that did not require an extraneous solvent, or a resin soluble in a solvent such as the Egyptians might have possessed. The former means a naturally occurring resin already liquid. Such resins, which are termed oleo-resins, are plentiful (pine and larch resins are of this class), the solvent being a volatile oil (oil of turpentine) that gradually evaporates on exposure. The only solvent that can be suggested that the ancient Egyptians might have used is a solution of natron in water and the only resin soluble in alkaline water solutions that is known to the author is shellac, from which an excellent varnish may be made by dissolving it in a solution of borax or ammonia in water, both of which materials, however, were probably unknown in ancient Egypt, though natron was well known and its possible use will be discussed later.

The oleo-resins, though nominally liquid, are at best of a thick syrupy consistency, which, however, may be reduced by warming. A natural oleo-resin applied warm, therefore, seems a possible explanation, and Laurie accepts this as being likely and states that 'As such volatile mediums as alcohol, turpentine and petroleum spirit were almost certainly unknown in ancient Egypt, we are driven to conclude that this varnish was a natural semi-liquid resin as obtained from the tree . . . probably laid on after warming.'³ Another suggestion that has been made is that the resin was applied in a finely powdered condition and was then liquified and spread by means of heat,⁴ but this does

¹ W. M. Flinders Petrie, *Mediam*, p. 29.

² Sherry being what is termed a 'fortified' wine (i.e. one to which alcohol in addition to that naturally present has been added) is the strongest in alcohol of any wine, except port (which was too highly coloured for the experiments), and almost certainly stronger than any of the old Egyptian wines.

³ A. P. Laurie, *The Materials of the Painter's Craft*, pp. 30-1.

⁴ R. S. Morrell, *Varnishes and their Compounds*, p. 2.

not appear feasible, and, in the case of a vertical surface, like a tomb wall, the resin would have had to be made to adhere first before it could have been spread. Laurie explains, too, that 'A solid resin, if fused by heat, cannot be spread on a surface properly and at once cracks on cooling,'¹ and for this reason Mackay thinks² that the varnish on tomb walls must have been melted on, because certain of the varnished surfaces are cracked.

The author has made a large number of experiments with a typical oleo-resin as obtained from the tree, namely Venice turpentine³ (larch turpentine; the oleo-resinous exudation of *Larix Europæa* or *Larix dedidua*), which at 20° C. (68° F.) was a viscous liquid, like thick syrup. Even in this condition it was found possible to apply it to wood (previously well sized with glue size) by means of a stiff bristle brush. The layer, however, though fairly thin, was not at first of uniform thickness and was covered with brush marks, but on standing a very short time the brush marks entirely disappeared and the layer became uniform. At temperatures of 30° C. (86° F.) and 35° C. (95° F.) the material, though less viscous, was still syrupy, but at 60° C. (140° F.) it became much thinner and could readily be taken up on a brush and applied to the wood, but the material cooled so quickly that, before it could be brushed on as a thin uniform coating, it became syrupy and much in the same state as at 20° C. (68° F.) and was similarly covered with brush marks and, except for the ease of filling the brush, there was practically no advantage in using it at the higher temperature. One great disadvantage of the particular oleo-resin tried, and therefore presumably of all oleo-resins, is the very slow drying. In the experiments made (the temperature of the room being about 15° C. to 20° C. (59° F. to 68° F.) during the day and lower at night) the 'varnish' took about five days before it was anything like dry, and even then it was a little tacky and remained so for about seven weeks when it was completely dry.

Experiments were also made with shellac (both button lac and garnet lac of the best qualities obtainable) and a solution of natron, using various proportions of shellac and various

¹ A. P. Laurie, *ibid.*

² E. Mackay, *op. cit.*, p. 37.

³ A specimen guaranteed pure was kindly supplied by Messrs. The British Drug Houses Limited, London.

strengths of natron. The solution that appeared to give the best results, so far as the experiments were carried, was 16 per cent of natron (containing 7 per cent of sodium chloride and 3 per cent. of sodium sulphate) and 20 per cent of shellac, which were boiled together for about ten minutes. This, while hot, could be brushed on to the wood (previously well sized with glue size), but, owing to the shellac becoming quickly insoluble (or largely insoluble) on cooling, the coating was not continuous, but patchy and fairly thick. This coating soon became hard, but it did not possess the glossy appearance of varnish, and both the solution and the applied coating were of a dark reddish-violet colour, totally unlike the colour of the ancient varnish. It seems quite probable that as a result of further experiments with other strengths of natron and shellac, and possibly also different ways of effecting the solution, a fairly thin coating might be obtained, but the experiments were discontinued since any coating obtainable would still have had the dark colour of the shellac that makes it impossible that this could have been the ancient varnish. Any artificial bleaching of the shellac at the early date when the varnish was used appears highly improbable.

The summary of the matter is that a coniferous oleo-resin, although it gives a fairly satisfactory varnish-like coating of a light brownish-yellow colour that resembles the ancient varnish in being soluble in alcohol, seems excluded because all these oleo-resins are soluble in spirits of turpentine, whereas the ancient varnish is insoluble, and shellac also seems to be excluded because, although readily soluble in alcohol and insoluble in turpentine, and so resembling the ancient varnish in these respects, the colour is much too dark. No other resins having the characteristics of the ancient varnish that could be dissolved in any solvent known to the ancient Egyptians can be suggested, though it seems probable that some resin (not a coniferous one) may ultimately be found that is sufficiently liquid to be applied with a stiff brush and that is insoluble in turpentine. As any such resin is likely to have been a product of western Asia and to have been used there for varnish before it became known in Egypt, the early history of the use of varnish in Persia might throw some light on the problem.

That such a useful material as varnish should have practically disappeared without leaving any substitute, as the Egyptian varnish did during the Ptolemaic and Roman periods,¹ is unusual, a possible explanation being that the source of supply of the resin was cut off, for example by wars in Asia.

WRITING MATERIALS

For the purposes of description the ancient Egyptian writing materials may be divided into two main classes, namely, those that were essential and those that were accessory. The primary materials comprised the pigments: the materials on which the pigments were placed in the act of writing and the implements (pens) used to transfer the pigments to the materials destined to receive them. The secondary materials included the grinders used by the scribes to prepare the pigments and the receptacles on, or in, which the pigments and implements were kept when not in use. All these objects may now be described.

Pigments

The pigments (ink) were in the form of small cakes of solid material, resembling, except in shape, modern water-colours and were generally of two kinds, red and black, though occasionally additional colours occur on a palette, these, however, being employed by the artist for illustrated scenes and not by the scribe in writing. One such palette, bearing the name of Mert-Aten, was found in the tomb of Tut-ankhamûn,² on which there had originally been six colours, only five, however, (black, green, red, white and yellow) now remaining, one (almost certainly blue) being missing.

The cakes of colours were probably made by mixing finely ground pigment with gum and water and drying, and they were used in the same manner as modern water-colours, namely, by dipping the brush in water and rubbing it on the pigment.

Garstang reports carbon and red ochre respectively for the black and red colours on a palette of Middle Kingdom date.³

¹ One instance only of the late use of varnish is known; see p. 300.

² Howard Carter, *The Tomb of Tut-ankh-Amen*, III, Pl. XXIII (A).

³ J. Garstang, *The Burial Customs of Ancient Egypt*, p. 77.

Laurie found the colours on an Egyptian palette dating from about 400 B.C. to consist respectively of charcoal, red ochre, gypsum, blue frit and yellow oxide of lead.¹

Barthoux examined the pigments from certain Egyptian palettes, which unfortunately were undated,² though judging from the results, some were of a very late period. The white was found to be calcium carbonate in some instances and magnesium carbonate in others; some of the red was red ochre and some red lead (minium); the brown was limonite (one form of oxide of iron); the yellow was yellow ochre containing in some instances calcium sulphate; the green is reported as powdered glass and the blue was a frit. As the use of minium in Egypt is very unlikely before Roman times, this specimen was probably of very late date. The calcium sulphate found with the yellow ochre was probably a naturally occurring impurity and the green described as glass was probably the well known artificial green frit. The black was carbon.

The author has examined nine specimens of pigments from palettes, one white, of Old Kingdom date, which proved to be calcium carbonate and eight of the Eighteenth Dynasty; one white, which was calcium sulphate, one bright yellow, which was orpiment (sulphide of arsenic); three red, all of which were red ochre; and three black, which were carbon.

Of the ink on documents, only one published analysis can be traced, which is by Wiesner, given in his account of the Rainer papyri from the Fayûm,³ which date from the ninth to the thirteenth century A.D. Wiesner states that the papyri are written with two different kinds of ink, one a carbon ink and the other an iron ink. Schubart also mentions two kinds of ink on papyrus,⁴ one black and one brown, the latter dating from the fourth century A.D., but the nature of this ink, the brown colour of which suggests an iron ink, apparently was not determined.

¹ A. P. Laurie, *Ancient Pigments and their Identification in Works of Art*, in *Archæologia*, LXIV (1913), pp. 318-19.

² J. Barthoux, *Les fards, pommades et couleurs dans l'antiquité*, in *Congrès internat. de Géog.*, Le Caire, Avril, 1925, IV (1926), pp. 257-8.

³ J. Wiesner, *Mittheilungen aus der Sammlung der Papyrus Erzherzog Rainer*, 1887, pp. ii-iii, 239, 240.

⁴ W. Schubart, *Einführung in die Papyruskunde*, 1918, p. 44.

Specimens of black ink on Coptic ostraca were found by Crum Brown to consist essentially of carbon.¹

Various specimens of black ink on documents have been examined by the author.² These included a number on ostraca (undated); a number on papyri, ranging in date from Roman times to the ninth century A.D., all of which were carbon, and a number on parchment documents dating from the seventh to the twelfth century A.D., in all of which cases the ink was an iron compound.

The carbon used for making ink was soot in most cases, probably generally scraped from cooking vessels, though occasionally specially prepared, the charcoal found by Laurie being exceptional. One method of making carbon for ink to be used for writing religious books, which was kindly supplied to the author by a priest of the Coptic Church, is as follows: Put a quantity of incense on the ground and round it place three stones or bricks, and resting on these, an earthenware dish bottom upwards, covered with a damp cloth; ignite the incense. The carbon formed is deposited on the dish, from which it is removed and made into ink by mixing with gum arabic and water. An old Arabic book in the Royal Library at Cairo (unfortunately anonymous and undated) contains a recipe for making what is called Persian ink. The method is to take date stones, put them in an earthenware vessel stoppered with clay and put the vessel over a fire until the next day, then remove, allow to cool, grind and sift the contents and make into ink with gum arabic and water. An ink such as this last, however, would be of poor quality and would contain very little free carbon.

Carbon is the oldest ink material known and in Egypt its use for writing can be dated back to a period before the beginning of the First Dynasty, that is before about 3400 B.C., Petrie having found 'dozens of pottery jars with ink inscriptions' of a date 'probably half-way back in the dynasty before Mena.'³ From the First Dynasty there are also examples of black ink writing, some on pieces of broken stone bowls⁴; one

¹ W. E. Crum, *Coptic Ostraca*, p. x, n.

² A. Lucas, *The Inks of Ancient and Modern Egypt*, in *Analyst*, 1922, pp. 9-14.

³ W. M. Flinders Petrie, *Abydos*, I, p. 3.

⁴ W. M. Flinders Petrie, *The Royal Tombs of the First Dynasty*, I, pp. 15, 21.

on a jar-sealing¹ and two on wooden tablets.^{2, 3} It is true that in none of these instances has the ink been analysed, but that it should be anything other than carbon is most unlikely.

Writing-grounds

The materials on which the ancient Egyptian writing was executed were very varied, and, taking them in alphabetical order, included bone (the shoulder blade of a camel with a Coptic inscription in ink is in the Cairo Museum); clay (several tablets of dried clay of Eleventh Dynasty date, some with incised inscriptions and some with ink inscriptions are in the Cairo Museum and, as the El-Amârna letters show, baked clay tablets were used for official correspondence between Egypt and western Asia in the Eighteenth Dynasty, the writing on these latter being in incised cuneiform characters in the Babylonian language); ivory; leather (several Egyptian manuscripts on leather are in the British Museum^{4, 5}); linen; metal (one specimen of 'bronze' and one of lead, both bearing writing in incised characters and both of Roman age are in the Cairo Museum); papyrus; parchment and vellum (the former being made from the skins of sheep and goats and the latter from the more delicate skins of calves and kids and neither having been employed before a very late period); pottery; reed (a large split reed with a Coptic inscription written in ink on the inside is in the Cairo Museum); stone (chiefly small flat pieces of limestone); wax (beeswax in the form of a thin uniform coating, usually coloured black, spread on wooden tablets, the writing being incised in the wax by means of a pointed implement called a stylus which was not used before Græco-Roman times); wood (both plain wood on which permanent inscriptions were written in ink, and wood coated with a thin coating of plaster, either white or coloured dark grey, on the former

¹ W. M. Flinders Petrie, *The Royal Tombs of the First Dynasty*, I, pp. 15, 21.

² W. M. Flinders Petrie, *The Royal Tombs of the Earliest Dynasties*, II, p. 38.

³ J. E. Quibell, *Excavations at Saqqara (1912-1914)*, p. 6.

⁴ S. R. K. Glanville, *The Mathematical Leather Roll in the British Museum*, in *Journal of Egyptian Archaeology*, XIII (1927), p. 232.

⁵ *Infra-Red Photographs of Illegible Leather Manuscripts*, in *The British Museum Quarterly*, VIII (1933), pp. 52-3.

of which temporary writing could be made with charcoal and afterwards effaced and on the latter temporary writing could be made with chalk and effaced). The most important writing material, however, was papyrus, which has already been dealt with in connexion with Fibres,¹ but cheaper substitutes were used for unimportant and ephemeral purposes, the principal of which were fragments of broken pottery and fragments of limestone, to both of which the name of ostraca has been given.

Pens

From a very early period until about the third century B.C., an interval of several thousand years, the ancient Egyptian writing implement was a piece of thin rush (not reed, as often stated) of suitable length, having one end bruised in order to separate the fibres and so make it into a fine brush: from the Græco-Roman period onwards this brush was superseded by a piece of reed of the thickness of the average modern penholder, cut with a split, blunt point like a quill pen, which is still employed to a slight, though rapidly decreasing, extent. Both these 'pens' have already been described in another connexion.²

Grinders

The grinders employed by the scribes to prepare their 'ink' were usually small rectangular pieces of stone, having a slight depression in the centre and a raised edge all round³ with a small pestle or muller (often cone-shaped) of similar stone,³ or occasionally instead of the pestle, a small stone spatula.

Palettes

The palettes, which were of various materials, were rectangular in shape and provided with depressions (usually circular, but sometimes rectangular) for the cakes of ink and a recess for holding the 'pens.'⁴ The materials included ivory (two examples of which were found in the tomb of Tut-ankhamûn⁵); wood; wood covered with gold (an example was in the tomb of Tut-ankhamûn⁵) and stone, generally alabaster or schist.

¹ See p. 136.

² See p. 133.

³ W. M. Flinders Petrie, *Objects of Daily Use*, Pl. LVI.

⁴ *Id.*, Pl. LVII.

⁵ Howard Carter, *The Tomb of Tut-ankb-Amen*, III, Pl. XXII.

In the tomb of Tut-ankhamûn, in addition to the normal palettes there were twelve others that were purely funerary,¹ having imitation cakes of pigment, some of stone and some of glass, and imitation pens of glass.

Sometimes separate receptacles were provided for the ink² and the pens, and two of the latter are in the Cairo Museum, one very ornate being from the tomb of Tut-ankhamûn³ and another, similar in shape though not so highly ornamented, having been found by Howard Carter many years before.⁴

Marking Ink

In connexion with ink, it may be mentioned that the Egyptians frequently had their linen garments marked with their names in 'ink,' one specimen of which was analysed by Dr. Ainsworth Mitchell and proved to be an organic material, free from carbon, that was not identified.⁵

DYEING MATERIALS

Very little is known about either the ancient Egyptian dyes or their methods of use. For fabrics the colours were chiefly blue, brown, green, red (various shades), and yellow; for leather, green, red and yellow and for ivory principally red, with occasionally dark-brown (or black) and green. Since artificial colouring matters were unknown, the dyes employed must have been natural and principally vegetable products, and one looks therefore to likely, and preferably local, sources for them.

Dyes

One plant that grew abundantly in the country anciently and that is still plentiful, which yields dyes is the safflower

¹ Howard Carter, *op. cit.*, p. 79.

² W. M. Flinders Petrie, *Objects of Daily Use*, Pl. LVI.

³ Howard Carter, *The Tomb of Tut-ankb-Amen*, III, Pl. XXII.

⁴ The Earl of Carnarvon and Howard Carter, *Five Years' Explorations at Thebes*, Pl. LXVI.

⁵ C. A. Mitchell, *Alleged Use of Marking Ink in Ancient Egypt*, in *The Analyst*, 1927, p. 18.

(*Carthamus tinctorius*),¹ from the flowers of which both a red and a yellow dye are obtained. The yellow is not now used, as it is soluble in water and hence not permanent, but the red is insoluble in water, though soluble in dilute solutions of alkalis, such as natron, and is employed for dyeing silk. The red dye is also extracted and used for colouring starch to make 'rouge' for toilet purposes and the flower petals are employed for colouring soups.

Many years ago Thomson suggested that the yellow dye of the ancient Egyptians was derived from the safflower,² but he was unable to prove this, though it has since been definitely established by Hübner, who identified it on fabrics of Twelfth Dynasty date.³ Hübner also found that another and slightly different shade of yellow of the same date was 'iron buff.'³

The ancient Egyptian blue dye has always been called indigo, meaning Indian indigo, and Thomson identified it about 100 years ago on ancient fabrics,² but unfortunately the date of the material is not stated. The author also found what he thought at the time was Indian indigo on an ancient Egyptian linen fabric, which was also undated. Petrie gives the date of the earliest indigo-dyed fabric in Egypt as the Twenty-second Dynasty.⁴ Indigo, however, is produced from a great variety of plants, of which two may be mentioned, namely Indian indigo, from the leaves of *Indigofera tinctoria*, and woad, from the leaves of *Isatis tinctoria*, the colouring matters of which, if not absolutely identical, are so much alike that it is difficult to distinguish one from the other. The dye does not occur ready formed in the plant, but is obtained by the artificial fermentation of the leaves, which contain a constituent (indican) that is converted into the blue indigo. The late Dr. J. B. Hurry, who was writing a book on woad, which was published shortly after

¹ Schweinfurth identified flowers of this plant, which are now in the Cairo Museum, from funerary garlands of Amenophis I (G. Schweinfurth, *Ueber Pflanzenreste aus alt-ägyptischen Gräben*, p. 365). These probably date from the re-wrapping of the mummy in about the Twenty-first Dynasty.

² J. Thomson, *London and Edinburgh Phil. Mag.*, 5, 1834.

³ J. Hübner, *The Colouring Matter of the Mummy Cloths*, in *The Tomb of Two Brothers*, M. A. Murray, pp. 70-7.

⁴ W. M. Flinders Petrie, *Descriptive Sociology, The Ancient Egyptians*, p. 49.

his death,¹ drew the author's attention to the fact that woad was cultivated in the Fayûm province of Egypt in early Christian times (from the first to the fourth century A.D.), as is proved by references to it in the *Oxyrhynchus Papyri*,^{2,3} and, therefore, what has been assumed to have been Indian indigo on ancient Egyptian fabrics may have been woad, though Indian indigo is not entirely excluded, since it was known to the Romans of Pliny's time (first century A.D.),⁴ though apparently only as a pigment for painting and not as a dye.

Although the Indian indigo plant will grow well in Egypt and was grown until comparatively recently, when the natural dye was largely superseded by the artificial product, there is no evidence that it was grown anciently, and almost certainly it was not, and, therefore, if the blue dye used were indigo, it was probably obtained from India.

Since there is no satisfactory permanent natural green dye, and since indigo, or other blue, mixed with yellow produces a green colour, the ancient green was probably made in this manner.

The dyes used for colouring leather have already been dealt with and it has been suggested⁵ that the red was kermes and that the yellow was derived from pomegranate rind.

It would be an easy matter to make a list of vegetable dyes that were used in one country or another anciently and that, therefore, might have been employed in Egypt, but any such speculation would only be misleading, since at present there is no evidence for their use.

Mordants

In the process of dyeing, two mediums are generally required, one being the dye and the other an agent or mordant, as it is termed, to fix the dye to the fabric, and Pliny states⁶ that the Egyptians employed a mordant, but unfortunately its nature is

¹ J. B. Hurry, *The Woad Plant and its Dye*.

² B. P. Grenfell and A. S. Hunt, *The Oxyrhynchus Papyri*, I, pp. 164, 166; II, pp. 270, 271; III, p. 282; IV, pp. 215-21; X, pp. 221-2; XIV, pp. 147-8.

³ A. S. Hunt, *The Oxyrhynchus Papyri*, VII, pp. 205-6.

⁴ XXXIII, 57; XXXV, 25, 27.

⁵ See p. 37.

⁶ XXXV, 42.

not specified, though it was probably alum, which occurs in the country and which was worked anciently.¹ Pliny's statement is as follows : ' In Egypt, too, they employ a very remarkable process for the colouring of tissues. After pressing the material, which is white at first, they saturate it, not with colours, but with mordants that are calculated to absorb colour. This done, the tissues still unchanged in appearance, are plunged into a cauldron of boiling dye, and are removed the next moment fully coloured. It is a singular fact, too, that although the dye in the pan is of one uniform colour, the material when taken out of it is of various colours, according to the nature of the mordants that have been respectively applied to it : these colours, too, will never wash out.'

The remains of a dye-house of Roman date were found at Athribis near Sohag by Petrie, who states² ' These vats . . . most of them are blue-black with indigo and some are red.'

The whole subject of the materials and methods used in dyeing in ancient Egypt both needs and merits further attention.

¹ See p. 215.

² W. M. Flinders Petrie, *Athribis*, p. 11.

CHAPTER XI

POTTERY

By pottery is meant ware made from clay, moulded into shape while wet and then hardened by being baked, faience, which has already been dealt with, not being pottery.

Clay

Clay is a colloidal, plastic material of secondary origin, derived from the disintegration and decomposition of certain kinds of primary rocks. The essential constituent of all clays is hydrated aluminium silicate, but with this are mixed variable, though usually small, proportions of natural impurities, chiefly alkalis (combined, not free); iron compounds (to which the colour is largely due); calcium carbonate; organic matter (humus); quartz sand and water, and it is the kind and amount of impurities present that condition the nature of the clay.

The water contained in clay is in two forms, one mechanically mixed, and it is on this that the plasticity depends, and the other chemically combined, and when clay is dried, the former, or interstitial water, is driven off and the material temporarily loses its softness and plasticity and becomes hard and friable, but if wetted it will take up water and become plastic again; when clay is more strongly heated or baked, the chemically combined water is also driven off and the material then becomes very hard and entirely loses its capacity for being acted upon by water and if wetted it does not revert to its former plastic condition.

The Egyptian clay employed for pottery making is essentially of two kinds, one of a brown or blackish colour when wet, but a brownish-grey when dry, which contains a comparatively large proportion of organic matter and iron compounds, together with varying amounts of sand, and this kind becomes brown

or red when heated, and the other of a brownish-grey colour when wet, but grey when dry, which contains very little organic matter, but a comparatively large proportion of calcium carbonate, which burns to a grey colour. The former occurs throughout the Delta and the Nile valley, whereas the latter is found only in a few localities, of which Qena and Ballas¹ in Upper Egypt are the most important.

Pottery making is one of the oldest of the arts and in Egypt dates back to neolithic times. At first the pots were of coarse material, crude in workmanship, devoid of finish and badly baked, but by the Badarian and the succeeding predynastic periods the Egyptian potter was producing wares that for beauty of form and finish are extraordinarily good.

In the making of a pottery vessel there are four main stages, namely, kneading the clay; shaping the clay into a pot; drying the pot and finally baking it, all of which may now be considered.

Kneading

Before clay can be fashioned into a pot, any small stones or other foreign material must first be picked out and the clay then brought to a uniform and right consistency, which is done in Egypt at the present day, and, therefore, doubtless also anciently, by thoroughly kneading it with water by means of the feet, with sometimes the addition, when the clay is too 'rich' or too 'fat,' of organic matter in the form of finely chopped straw, fine chaff or powdered animal dung, which are used in order to reduce the stickiness (which makes it difficult to manipulate), to expedite the drying and also to prevent undue shrinkage with its accompanying cracking and distortion during drying. This 'tempering' of the clay is not merely a modern device,² but was employed anciently, as is proved by the fact that it is not unusual to find in predynastic and early dynastic pottery either chopped straw or evidence that this had been used and had burned out during baking.³

¹ An analysis of the Ballas clay will be found on p. 433.

² For references, see A. Lucas, *The Nature of the Colour of Pottery*, in *Journal Royal Anthropol. Inst.*, LIX (1929), p. 114.

³ J. E. Quibell, *Archaic Objects*, in *Cat. Gén. du Musée du Caire*, pp. 137-77.

Shaping

In the early days of pottery making in Egypt, that is during neolithic and predynastic times, pots were made by hand, and Petrie states¹ that 'The first use of the wheel regularly is for the great jars of the royal factory in the 1st Dynasty': Reisner says² that the beginning of wheel-made pottery dates from the reign of Khasekhemui and the accession of Sneferu and Frankfort states³ that the potter's wheel was only generally used in Egypt 'about the Fourth Dynasty, though sporadically appearing since the First.' This wheel in its early and simple form was merely a small circular platform, rotated slowly by hand, on which the clay was placed while being shaped. Its nature and mode of use are depicted on the wall of a Fifth Dynasty tomb at Saqqâra⁴ and on the walls of two Twelfth Dynasty tombs at Beni Hasan.⁵ Wheel-made pottery, however, has never entirely displaced the hand-made variety in Egypt, the latter being still made to some extent at the present day.⁶

Drying

After the pot is made it must be dried before baking, otherwise the rapid vaporization and escape of the mechanically-held water that would take place in the fire or kiln would rupture the pot.

Baking

Finally, the pot is baked in order to drive off the chemically-combined water, the loss of which is necessary to convert the clay from its original weak, friable state, in which it is softened by water, into a hard, durable, stone-like mass, unacted upon by water.

As for the manner of baking, there can be little doubt that at first the dried pots were baked on the ground as a mixed heap of pots and fuel, probably covered over with animal dung

¹ W. M. Flinders Petrie, *Descriptive Sociology, Ancient Egyptians*, p. 57.

² G. A. Reisner, *A Provincial Cemetery of the Pyramid Age, Naga-ed-Dêr*, III, p. 185.

³ H. Frankfort, *Studies in the Early Pottery of the Near East*, I, p. 107, n. 5.

⁴ G. Steindorff, *Das Grab des Ti*, Pls. 83, 84.

⁵ P. E. Newberry, *Beni Hasan*, I, Pl. XI; 11, Pl. VII.

⁶ W. S. Blackman, *The Fellâhîn of Upper Egypt*, pp. 136-7.

to conserve the heat, as is done to-day in the Sudan and by primitive people elsewhere. The fuel available was principally straw, chaff, animal dung, reeds, rushes and sedges. At a later date, the heap might have been surrounded by a low wall of clay and the dung covering replaced by clay and finally a simple kiln with a separation between the pots and the fuel would be evolved. As a pottery kiln is shown in a Fifth Dynasty tomb at Saqqâra,¹ its use must have been well established at that date: pottery kilns are also depicted in two Twelfth Dynasty tombs at Beni Hasan.²

Colour

Important features of pottery are its colour, polish (if any), and decoration (if any), which may now be considered.

The colour of pottery depends upon many factors, the principal of which are the kind of clay used, the surface treatment of the pots (if any) and the nature of the firing.

Even a mere enumeration of the different colours of pottery is not without difficulty, partly on account of the large variety of shades or gradations of colour that occur and partly because some of the colours are usually described by terms such as 'drab' and 'buff' that lack precision of meaning and, therefore, are not always employed in the same sense. The colours of the plain, unpainted and undecorated pottery that may specially be mentioned are brown earth colour, black, red, partly black and partly red, and grey, and the nature and cause of these colours will now be considered.

Brown Ware

A brown earth colour in pottery is simply that of the clay used, which has not been modified, or only slightly modified (apart from any lightening of the colour due to drying), by the very imperfect baking, the black patches often present being smoke stains and manifestly, therefore, the fire must have been a poor and smoky one. This coloration, although usually

¹ G. Steindorff, *Das Grab des Ti*, Pl. 84. In plates Nos. 85 and 86 the two scenes described as '*Brennen von Töpfen*' depict the heating of pots in connexion with bread baking and not the burning of pottery.

² P. E. Newberry, *Beni Hasan*, I, Pl. XI; II, Pl. VII.

confined to the most primitive pottery, may occur at almost any period.

Black Ware

Black pots were probably first produced occasionally by accident, but accident cannot account for a continuous production of black ware, which doubtless arose from a deliberate attempt to cover up the inevitable and disfiguring smoke stains of the earliest pottery by utilizing a smoky fire, such as caused them, to make the pots wholly black, or as so well expressed by Myres,¹ 'what had begun as an accidental disfigurement had been seized and utilized . . . and developed into an intentional technique.' It would soon be realized, however, that a fire continuously smoky was not satisfactory for the production of well-baked pottery and that the best way of obtaining pots that were both hard and black was to bake them first in a fire as hot as could be obtained and to blacken them after the baking by exposing them to dense smoke.

Black pottery is not at all uncommon in Egypt at the present day and it is made in a very simple manner. Ordinary red or reddish pottery is first made in the usual way and at the end of the baking, when the flames of the fuel have died down, but while the pots are still red-hot, the furnace door is opened and some smoke-producing combustible (in one factory it was pitch and in another a mixture of coal and pitch) is thrown on to the hot ashes. This, which does not come into contact with the pottery, produces dense smoke, which blackens the pots. The resulting ware, although generally described as black, is really not black, but a very dark grey, not only on both surfaces, but through to the centre, with, however, sometimes a suspicion of brown just below the surface.

Crowfoot² and other writers³ describe primitive modern processes of making black pottery in which the pots direct from the fire and still red-hot are buried in and covered with

¹ J. L. Myres, *The Early Pot Fabrics of Asia Minor*, in *Journ. Royal Anthropol. Inst.*, xxxiii (1903), p. 368.

² J. W. Crowfoot, *Further Notes on Pottery*, in *Sudan Notes and Records*, VIII (1925), p. 131.

³ Several quoted by Crowfoot.

organic material, such as chaff, dung and leaves, which in contact with the hot pots smoulders and gives off dense smoke that in a very short time blackens the pots, not merely on the surface, but throughout if the vessels are thin, or well into the substance of the ware when the vessels are thick.

The author has produced black pottery on a small scale in the laboratory in the same manner by heating ancient red ware (fragments), modern red ware (miniature pots) and modern grey ware (fragments and miniature pots) in an electric furnace until red-hot and then immediately burying them in sawdust, chopped straw or chaff and allowing them to remain for various periods of time varying from a few minutes to about half an hour. The sawdust, chopped straw or chaff, becoming carbonized, produced dense smoke, which not only blackened the surface of the pottery, but definitely penetrated below the surface, and when the pottery was broken it was seen to be black at both sides with a grey zone in the centre. In other experiments pieces of modern grey ware (cold) were suspended by wire inside and near the top of a metal cylinder, which was closed except for the two small holes in the top through which the wire passed. At the bottom of the cylinder a deep layer of sawdust, chopped straw or chaff was placed and heat was applied to the outside of the bottom of the cylinder until smoke ceased to issue from the top. In every instance the pottery was blackened and in every instance, too, the black penetrated below the surface, in some cases the ware becoming grey through to the centre. There is not any layer of soot on the surface of this blackened pottery and it may be handled freely without soiling the hands and even when rubbed with a clean white fabric this is only slightly discoloured.

In this connexion it may be mentioned that, although smoke consists of solid particles, these are very minute, being of the order of from about one-thousandth of a millimetre to about one-hundred-thousandth of a millimetre in diameter¹ and they are so small that they cannot separately be seen by the naked eye, the 'blacks' or 'smuts' observed when a chimney or lamp smokes not being what is scientifically meant by smoke, but immensely larger particles. It may be pointed out, too,

¹ W. E. Gibbs, *Clouds and Smoke*, p. 130.

that the ancient pottery is often of a very porous nature and that in any application of smoke, such as described, the penetration of the smoke would be aided by the contraction of the air in the pores of the pottery as cooling progressed. The carbonization during baking of any organic matter present in the clay would intensify any black colour due to smoke, especially in the centre of the ware.

Although, as shown, pottery does undoubtedly become, not only blackened, but blackened throughout in the presence of dense smoke, it has been stated by several writers ^{1, 2} that the smoke is not an essential factor; that smoke cannot penetrate pottery and that the phenomenon is not due to the smoke but is caused by reducing gases accompanying the smoke that convert the red oxide of iron present into a black modification. Whether such a change can or does take place may now be discussed.

That the colour of black pottery may be due to the presence of black oxide of iron produced from red oxide by the action of reducing gases in the fire is theoretically possible and from a chemical point of view is very attractive, but it is merely an assumption rendered plausible by the facts that certain oxides of iron are black; that reducing gases (probably principally carbon monoxide) may have been present in small amount during the firing of pottery in a primitive manner and that it is possible under special conditions in a laboratory to change the red of red pottery to a dark bluish-grey colour. That any such reduction actually occurred during the baking of early pottery has never been proved; no evidence whatever that it did occur is offered by the supporters of the hypothesis and it is contrary to the available facts, which may now be considered.

Frankfort states ³ that a black colour due to black oxide of iron produced from red oxide by reduction 'can clearly be distinguished' from a black colour due to carbonaceous matter because the former is changed back to the original red on heating (from which the black may be regenerated by further reduction),

¹ W. M. Flinders Petrie, *The Arts and Crafts of Ancient Egypt*, pp. 130-1.

² E. J. Forsdyke, *The Pottery called Minyan Ware*, in *Journal of Hellenic Studies*, xxxiv (1914), p. 139.

³ H. Frankfort, *Studies in Early Pottery of the Near East*, I, p. 10.

whereas the latter is burned out and disappears. This argument, however, contains several omissions and fallacies. Thus the nature of the clay is not taken into account and, although it is true that if black pottery when heated becomes 'pale or yellow-red' the black must have been due to the presence of carbonaceous matter (including smoke), which has been burned out by the heat, there is more than this, namely, that the clay must either have been free from iron compounds or contained them in only very small proportion, or that these must have been of such a kind, or were associated with calcium carbonate in such a manner, that they did not produce red oxide when heated. And the fact that certain black pottery became red when heated is not proof that the black was due to black oxide of iron, unless it could be shown that the clay was not of the red-burning type, since pottery blackened by carbonaceous matter (including smoke) would behave exactly in the same manner if the clay were a red-burning one. The difference in the behaviour of the two kinds of black pottery referred to by Frankfort was almost certainly due to the fact that the one was made from a red-burning clay and the other was not.

As there appears to be a certain amount of confusion respecting the oxides of iron (the black colour of ancient pottery having been attributed by different writers to different oxides, for example, by Frankfort¹ and Forsdyke² to ferrous oxide; by Petrie³ to magnetic oxide and by Franchet⁴ partly to ferrous oxide and partly to magnetic oxide) these oxides may be considered.

There are three oxides of iron, ferrous oxide, which is black; ferrous-ferric oxide or magnetic oxide, which is also black and ferric oxide, which is red. Manifestly, therefore, any black oxide must be either ferrous oxide or magnetic oxide.

Ferrous oxide may be produced in the laboratory by heating

¹ H. Frankfort, *op. cit.*, I, p. 10; II, p. 65, n. 2; p. 141, n. 2.

² E. J. Forsdyke, *op. cit.*, pp. 137-9.

³ W. M. Flinders Petrie, (a) *The Arts and Crafts of Ancient Egypt*, p. 130; (b) in *Cairo Scientific Journal*, VI (1912), p. 67; (c) *Diospolis Parva*, p. 13; (d) W. M. Flinders Petrie and J. E. Quibell, *Naqada and Ballas*, pp. 12, 37.

⁴ L. Franchet, *Céramique Primitive*, pp. 21, 34, 84, 136, 137.

ferric oxide either in a current of hydrogen to about 300°C .^{1, 2} or in an atmosphere of hydrogen and steam to a much higher temperature (700°C . to 1000°C .²). Neither of these temperatures, however, is that at which primitive pottery was baked, 300°C . being too low and 700°C .– 1000°C . too high, the dehydration temperature of clay being from about 500°C . to about 600°C . Also the atmosphere surrounding pots fired in a primitive manner is neither an atmosphere of hydrogen, nor of hydrogen and steam at any time and, although a very small amount of hydrogen might have been produced by the combustion of the fuel, this could not possibly have continued to exist in the free state in an open fire, but would at once have been burned up with the formation of water vapour. Another and insuperable objection to the black of ancient pottery being due to ferrous oxide is that this oxide is an extremely unstable substance, which cannot exist in the free state, but which is oxidized immediately it is formed. But possibly those who mention ferrous oxide, not being chemists, do not mean the free oxide, but a ferrous compound that for the sake of convenience may be regarded as consisting of this oxide combined with some other substance, such for instance as silica, but in which the oxide has lost its separate identity the real body present in the example given being ferrous silicate. This would seem to be indicated in at least one instance³ by a reference to the Staffordshire blue brick (the colour of which is probably due to ferrous silicate) as an example of the reduction of ferric oxide to ferrous oxide. As, however, the brick is *blue* and not black, its colour cannot be any proof that the colouring agent of *black* pottery (which is very black and not blue-black) is either ferrous oxide or ferrous silicate. Moreover, the Staffordshire blue brick is produced in a modern kiln, where the air conditions may be regulated to a nicety and where a reducing atmosphere may readily be obtained and maintained, whereas the early ancient 'black pottery was fired in a primitive manner in an open fire with an atmosphere that cannot have been a

¹ T. Turner, in *A Dict. of Applied Chemistry* (Sir Ed. Thorpe), III (1928), p. 677.

² Roscoe and Schorlemmer, *A Treatise on Chemistry*, II (1913), p. 1218.

³ E. J. Forsdyke, *op. cit.*, p. 140.

reducing one. The absence of a highly oxidizing atmosphere, as proved by the presence of smoke, is sometimes taken to mean that, therefore, the atmosphere must be a reducing one, but this is not so. The presence of smoke indicates a comparatively low temperature and the partial exclusion of air, but not the presence of a reducing atmosphere, this being not merely the absence of the usual compliment of oxygen, or even the momentary presence of small proportions of reducing gases, but the presence of a considerable proportion of such gases operating over a somewhat lengthy period of time.

Magnetic oxide, which Petrie states is the colouring matter of the ancient black pottery, may be produced in the laboratory by reducing the red oxide by means of hydrogen or carbon monoxide at a temperature of $500^{\circ}\text{C}.$ ¹ or by a mixture of hydrogen and steam at $400^{\circ}\text{C}.$,² but the primitive method of baking did not provide an atmosphere of hydrogen, carbon monoxide, hydrogen and steam, or a reducing atmosphere of any kind. Ferric oxide may also be converted into magnetic oxide by heating it to a very high temperature (above $1350^{\circ}\text{C}.$),^{3, 4} a temperature that it is impossible could have been attained under the conditions of the firing of primitive pottery. Usually, too, when ferric oxide is heated in a reducing atmosphere it is metallic iron that is formed. Also if the black is magnetic oxide, it should be magnetic, which is not so. When powdered and tested with a magnet a few tiny particles are found that are magnetic, but these are not nearly sufficient in quantity to account for the black colour and, as magnetic oxide of iron is a common constituent of Egyptian clays, the very small amount of this material present in the black pottery is almost certainly original to the clay, and has not been produced by any chemical reduction of red oxide during baking.⁵

Many of the proofs given that the black of the ancient Egyptian black pottery is not due to black oxide of iron are

¹ H. Abraham and R. Planiol, *Journal Chemical Society*, Abs. CXXVIII (1925), II, pp. 587-8.

² Roscoe and Schorlemmer, *op. cit.*, p. 1220.

³ *Id.*, p. 1222.

⁴ T. Turner, *op. cit.*, pp. 677-8.

⁵ A. Hopwood, *Magnetic Materials in Claywares*, in *Proc. Royal Soc., A*, LXXXIX (1914), pp. 21-30.

negative ones, but there are two good positive proofs, namely, first, that a large number of specimens of both ancient and modern black ware have been analysed and the presence of carbon (smoke) proved chemically in every instance, and second, that pottery made from grey-burning clay without any wash of red ochre, where there is not any red oxide to be reduced, may be blackened in the manner described.

Red Ware

Among the brown smoke-stained pots at first produced, there would probably have been an occasional one that was red, because it happened to have been better baked than usual and, as a hotter and brighter fire became more common, so the colour of the pots would improve, until eventually a good red would be quite ordinary. But meanwhile it was discovered that a red colour could be obtained by coating the pots with a wash of red earth (red ochre).

The various shades of red (including brown) of pottery are always caused by the presence of red oxide of iron, which is generally due to the use of clay containing a relatively large proportion of iron compounds of such a nature that they become converted into red oxide when strongly heated, but, as already mentioned, the red may be caused by the application of a wash of red oxide to the surface.

Red pottery may be either uniformly red throughout or, more generally (especially in the case of the thicker and coarser kinds), it is red on both surfaces, but grey or black in the centre, this central zone varying from a thin line to a broad band. The grey or black is due to the carbonization of organic matter, either contained as a natural impurity in the clay in the form of decayed material of vegetable origin (humus), an occurrence by no means infrequent, or else artificially added in order to temper the clay.¹ When clay containing organic matter is heated with free access of air this organic matter at first carbonizes and becomes black, the action beginning from the surface and slowly extending inwards and, if the walls of the vessel are thin, or the heat considerable or long continued, this blackened matter then gradually burns away, with the simul-

¹ See p. 317.

taneous conversion of the iron compounds into red oxide, but if the vessel is thick, or the heat not great or not of long duration, the organic matter in the thickness of the ware is merely charred and remains, giving a grey or black colour to the zone in the centre. In order to produce a good red surface, not only must the clay be of the right kind, but the fire must be hot and free from smoke at the end of the baking and, with such a fire, any smoke stains produced in the earlier stages of the baking are burned off.

When red oxide is applied to the surface of a vessel, it is always in the form of a red ferruginous earth made into a wash with water. As this red is a natural earthy form of hæmatite, it is often termed hæmatite, but it will save confusion and will serve to distinguish it from the black opaque mineral with a metallic lustre employed for beads, amulets and other small objects, if it be given the better and more correct name of red ochre.

The author believes that the use of a red wash on ancient Egyptian pottery is less common than is supposed. Polishing so modifies the surface of clay that the light is reflected differently, which naturally affects the colour and may suggest the use of a wash when there is none.

Black and Red Ware

In addition to black pottery and red pottery, a pot partly black and partly red became fashionable at an early date, probably as the result of the accidental production of a few such pots. The Badarian and predynastic black-and-red wares take the form of a black top, with often also a black interior, to an otherwise red vessel.

The black of this black-topped ware, like that of the entirely black ware already dealt with, is a carbon black, that is to say it is a smoke black and not an oxide of iron black, as often stated. The proofs of this are the same as those already given for the entirely black ware and may briefly be recapitulated.

The black cannot be ferrous oxide, as the formation of this compound in pottery is impossible; nor can it be ferrous silicate, since this is not black, but bluish-grey; although the black may contain a few magnetic particles derived from

the clay used, it is not magnetic and, therefore, it cannot be magnetic oxide ; the atmosphere of the open fire employed for baking the early pottery, although it may have contained a very small proportion of reducing gases (chiefly carbon monoxide), could not have been a reducing one of the kind or to the extent required to reduce red oxide of iron to black oxide, the presence of smoke not being evidence (as it is sometimes thought to be) of a reducing atmosphere, but merely a sign of the absence of a highly oxidizing one, which is only a negative condition, whereas a reducing atmosphere means the positive presence of a large proportion of reducing gases ; also, when ferric oxide is heated in a reducing atmosphere it is usually metallic iron that is produced ; the black, too, always gives the reactions for carbon (smoke) when tested. Moreover, the black top and black interior may be duplicated under conditions that make it impossible that it should be the product of the reduction of red oxide to black oxide, these conditions being the very short time (a few minutes only) necessary to produce the blackening, the rapidly falling temperature of the pottery during the operation and particularly that the black may be produced in the absence of red oxide with clay (without any wash of red ochre), that is not red-burning but grey-burning. Finally, it may readily be proved that the black is not due to any compound (whether ferrous oxide, ferrous silicate or magnetic oxide) formed by the reduction of red ferric oxide by taking two sherds, if possible from the same pot, one from the red body and the other from the black rim, reducing the red of the former in the laboratory by means of hydrogen and comparing the result with the black sherd. The difference is very marked. The colour of the treated sherd is a dark bluish-grey and not black, and on powdering it and adding hydrochloric acid an immediate and vigorous reaction is produced, and on continued treatment practically all the colour disappears, leaving a very light-grey (almost white) coloured residue from which carbon and carbonaceous matter are manifestly absent and, if the experiment has been carried out with due precautions against oxidation, the solution on testing is found to contain iron compounds in the ferrous condition. In the case of the sherd originally black, this, under identical conditions, shows no immediate or pro-

nounced action with the acid and, even after prolonged treatment, the residue remains black; there are no ferrous compounds in the solution and the black gives the tests for carbon.

Before being in a position to explain the mode of production of this black-topped ware, it is necessary to know something more about it than the mere fact that one part of a pot is red and another black, and the detailed description of this pottery may, therefore, be given.

The outside of the body of the pot is red, this red being generally thicker than can be accounted for by either a red slip or a red wash and, therefore, the ware itself must have been baked red; the red does not penetrate through the ware, nor even as a rule to the centre, but there is always a thick black stratum below it; a little red may occasionally be seen on the rim (generally inside) amid the black,¹ showing that the surface had originally been red and was subsequently covered with black, some of the red, however, having escaped the action. The top (mouth) of the pot and often also the interior are black; the black is black throughout²; the ware below the red, as already stated, is also black.

There are only two ways in which such pottery could have been made, namely, (a) by the simultaneous production of the red of the body (apart from any wash of red ochre) and the black of the interior and rim, or (b) by producing ware wholly red first and then by a secondary operation blackening the interior and rim.

The first method was adopted by Mr. H. L. Mercer, a pottery manufacturer of Pennsylvania, who in one continuous operation made excellent imitations of the red-bodied black-topped ware, which are now in the Pitt-Rivers Museum at Oxford. His description of the process is as follows³: 'Having made a pot of ferruginous clay which in a clear kiln fire would burn red, I rubbed red ochre diluted in water upon it with the hand when half dry. Immediately polishing the surface by rubbing

¹ As examples of this may be mentioned pots Nos. 2002, 2007, 2012, 2015 and 18812 (and probably others) of those described by von Bissing (Fr. W. von Bissing, *Tongefässe*, I, in *Cat. Gén. du Musée du Caire*).

² Except for the occasional red on the rim.

³ H. L. Mercer, in *Areika* (D. Randall-MacIver and C. L. Woolley), p. 17.

with the circumference of a blown glass bottle in lieu of a pebble, I next thoroughly dried the pot and then stood it upside down with the rim buried an inch deep in a layer of rather fine white pine sawdust in the centre of which immediately under the vessel I placed a piece of resin of the size of a chestnut. Over the bowl thus arranged I so bent a piece of common wire netting (meshed at about two inches) as to entirely surround and over-arch the pot at a distance from it of about two inches. Both wire and sawdust stood within a circle of about three feet in diameter of loosely piled stones about one foot high. Upon this I threw about a bushel of finely chipped dry rye straw so as to fill the stone circle and entirely cover the bowl and wire. The straw when ignited burnt about three-quarters of an hour, leaving the pot when cool a duplicate (even to the waving buff-grey zone below the black) of the original specimen.'

At one time the author thought and stated¹ that some such process as that of Mercer (without of course the wire netting, but with some other method of keeping the fuel from close contact with the pot) had been practised anciently and, although this may have been so (as manifestly it is not impossible) he is unable to conjecture how it could have been done, and Petrie, who first suggested this method,² gives no explanation beyond that the pots were baked mouth downwards with the rims in the ashes. It may be pointed out, too, that in order to bake a large number of pots together with all the rims in the ashes, a considerable area of ground would have been required. Ashes, too, are only produced towards the end of the baking, when the smoke is over. The author now thinks it more likely that the method employed consisted of two distinct operations (as in the making of modern black pottery in Egypt), the first being the making of a red pot (the red of the clay being enhanced in some instances by a wash of red ochre) and the second being the subjecting of the rim and interior of the pot to the action of dense smoke in order to blacken them, this second operation (first suggested as being likely by Mr. J. W. Crowfoot)³ being

¹ A. Lucas, *The Nature of the Colour of Pottery*, in *Journal, Royal Anthropol. Inst.*, LIX (1929), pp. 127-9.

² W. M. Flinders Petrie, *The Arts and Crafts of Ancient Egypt*, p. 130.

³ A. Lucas, *op. cit.*, p. 129, n. 2.

analogous to that practised in the Sudan and elsewhere at the present day and already described,¹ but instead of the whole pot being covered with chaff or other material, which produces a pot entirely black, the rim only would have been covered, as only this and the interior had to be blackened.

The obvious way of carrying out the operation seemed to be to stand the pots red-hot from the fire mouth downwards on the fuel and this method, therefore, was tried. Miniature pots of two different kinds of clay were procured from a local potter, who supplied them wet; these were partially dried, coated with a thin wash of red ochre by smearing it on with the fingers, polished with a quartz pebble, thoroughly dried, baked in a small electric muffle furnace, and when red-hot placed mouth downwards on a layer of sawdust (which was the fuel chosen) in which the rim was buried. The result was a red pot with a black rim and generally, though not always, a black interior, but the red body at first was almost always badly smoke-stained. In order to avoid this staining, various modifications of the method were tried and eventually it became clear that the exact temperature of the pots was of little importance, provided they were hot enough to char the fuel and not sufficiently hot to enflame it, and that the principal precaution necessary was to prevent the sawdust giving off smoke from the top, which could be done by manipulating it in such a manner that the smouldering took place entirely beneath the surface and that practically no smoke escaped, which was effected by pressing down the sawdust and covering it up with fresh material whenever any signs of burning manifested themselves, or better, by covering the sawdust, after the pot had been placed in position, with a thin layer of dry earth or sand.² There is not any thick layer of soot on the black rim or black interior, which may be handled without soiling the hands and, even when rubbed with a clean white fabric this is only slightly blackened.

Another way of avoiding smoke stains on the bodies of the

¹ See p. 319.

² It occasionally happened that a pot accidentally fell over on to its side in the sawdust, which charred in contact with the hot clay and stained the pot, and some of the stains on the ancient pottery may have been caused in this manner.

pots is by burying them, direct from the furnace, mouth upwards in sand, leaving only the rims exposed: covering the rims, while still hot, with sawdust and placing a little sawdust inside the pots. Although this method is very satisfactory in the laboratory, it might not be practical on a large scale, as to bury a number of red-hot pots upright and very quickly, before they have time to cool, in sand or earth is not easy and in winter the rims of the pots would probably cool so rapidly that they would not be hot enough to char the sawdust and, if the ground were wet, it would be impossible without cracking the pots.

Grey Ware

The various shades of grey (generally ash-grey or greenish-grey, but sometimes brownish-grey) of ancient Egyptian pottery are due to the use of a special kind of clay (brownish-grey colour) practically free from organic matter (which is dark coloured and which darkens further on heating, unless it is entirely burned away) and either free from iron compounds or if these were present in more than a small proportion (as was probable) calcium carbonate must also have been present, as it is only such clays that do not become red, but greenish-grey, when strongly heated, although when only lightly baked they are often of a slight reddish tint, which is the opposite of what might be expected, and the opposite of what occurs with many clays, usually the greater the heat the redder the ware. The Qena and Ballâs clays of which the modern *qulleh* and *ballâs* are made are of this type.¹ Grey pottery occasionally shows a dark zone in the centre of the ware, which is due to the same cause as in the case of red pottery, namely the carbonization of organic matter present in the clay.

Polish

The only period during which a clay pot can be polished by simple rubbing with a pebble or other hard smooth object is when the clay is almost but not quite dry. This is a phenomenon depending upon the physical nature of clay, which is a material

¹ An analysis of a present-day typical pottery clay from Ballâs shows it to contain a comparatively large proportion of iron compounds (6 per cent) and more than 20 per cent of calcium carbonate. For details of analysis, see p. 433.

that it is impossible to polish by simple rubbing when wet or when quite dry (as just before baking) or after being hardened by baking, and it is only by the use of certain materials such as oil, fat, wax or graphite (blacklead) that it is possible to polish dry or baked clay. The polish produced by rubbing varies with the nature of the clay, being more brilliant on a 'rich,' 'fat,' or well levigated clay than on a poor, calcareous or coarse one.

When an unbaked clay vessel, either with or without a wash of red ochre, is pebble-polished and then baked, the colour is so altered, first by the polishing and then by the baking that often it hardly seems to be the same vessel, which facts need to be taken into account before deciding whether or not a vessel has been treated with a slip or wash.

The polish applied to clays before baking not only persists after baking and blackening, but is often more brilliant on the final black than it was on the original red, probably purely an optical effect due to the different manner in which the two colours reflect the light. With certain ancient red-polished sherds that were blackened by making them red-hot and then burying them in sawdust, the polish not only became more brilliant, but acquired the metallic sheen seen on much of the black of the Badarian and predynastic black-topped ware, which is very like a graphite polish in appearance, which of course it cannot have been on the treated sherds and which it probably is not on the Badarian and predynastic pottery. A graphite polish, however, was found by Reisner¹ on some of the ware from the Middle Kingdom Egyptian colony at Kerma in the Sudan, and graphite is used to-day in certain districts of the Sudan for giving a polish to a surface already black,² but there is not any evidence for its use in Egypt.

Decoration

The predynastic pottery is often decorated with incised or painted designs or painted scenes. The incised designs on black ware are filled in with white pigment, as otherwise they would hardly be visible on the dark surface. The painted designs

¹ G. A. Reisner, *Excavations at Kerma*, IV-V, p. 329.

² J. W. Crowfoot, *op. cit.*, pp. 133-4.

are generally executed in white or yellowish-white on red ware, and the painted scenes (often boats and large wading birds) are in reddish-brown or brownish-grey on light red ware. At a much later date additional colours, chiefly light blue, various shades of red, black and, very occasionally, yellow were employed and sometimes ordinary coarse red ware was coated with white.

No record of the analyses of the pigments used on the pre-dynastic pottery can be traced, but they are certainly all mineral colours, the white being either calcium carbonate or calcium sulphate and the reddish-brown being an iron oxide (ochre). Various specimens of the pigments from painted pottery of the Eighteenth Dynasty found at Giza and El-Amârna respectively have, however, been analysed by the author, who found the blue to be the usual Egyptian blue frit; the red to be red ochre and the black to be carbon. The white coating on a number of red pottery jars from the tomb of Tut-ankhamûn was also examined and proved to be calcium carbonate (chalk, whitening).

CHAPTER XII

PRECIOUS AND SEMI-PRECIOUS STONES

The stones used in ancient Egypt for amulets, beads, jewellery, scarabs and other personal ornaments, although doubtless all costly and highly prized at the time, include many that nowadays would not be called precious, but, at the most semi-precious and in some instances not even that. Many of these stones were also employed as inlay for the decoration of boxes, coffins, furniture and other objects.

The principal stones used were agate, amethyst, beryl, calcite, carnelian, chalcedony, coral, felspar, garnet, hæmatite, jade, jasper, lapis lazuli, malachite, olivine, onyx, pearl, rock crystal, sard, sardonyx and turquoise. With these it will be convenient to include amber and other resins, which, although not stones, were regarded as semi-precious materials and were used for many of the purposes of gem stones. The diamond, opal, ruby and sapphire were not known to the ancient Egyptians.

Precious stones are frequently mentioned in the ancient records as having been employed for particular purposes and as having been received as tribute or taken among the spoils of war and, although some of these stones are referred to individually by name, the translation of the names is still often uncertain. Pliny mentions about thirty different kinds of precious stones obtained from Egypt and Ethiopia,¹ but only a few of these can be identified.

Many of the stones enumerated were employed as early as Badarian and predynastic times, while others only came into use at a very late period and, with a few exceptions, they were all local products.

¹ xxxvii.

Agate, Onyx, Sardonyx

Agate, onyx and sardonyx are all banded forms of chalcedony and, being very closely related, they are often classed together as agate; they all consist of silica,¹ the principal difference between them being in the colour of the bands: in agate, the bands, which are frequently irregular and ill-defined, but usually more or less concentric, are generally white and brown, with sometimes a little blue: in onyx and sardonyx the bands are generally straight and comparatively regular, in onyx being milk-white alternating with black and in sardonyx white alternating with reddish-brown or red, this stone, as its name indicates, consisting of onyx stratified with bands of sard. The greater part of the agate, onyx and sardonyx, especially the onyx, used for jewellery at the present day is artificially stained.

Agate occurs plentifully in Egypt, chiefly in the form of pebbles, but it has also been found in small quantity associated with jasper and chalcedony in a dyke rock at the head of Wâdi Abu Gerîda in the eastern desert.² Onyx and sardonyx probably also occur in Egypt, though no mention of them can be found in the geological reports. Pliny refers to Egyptian agate from Thebes and states that it is destitute of red and white veins and is an antidote to scorpion poison.³

Agate pebbles have often been found in predynastic graves⁴ and both agate beads^{5, 6} and onyx beads⁷ of this date are known. The earliest use of sardonyx that can be traced is from the Twenty-second Dynasty,⁷ though the disks of Nineteenth Dynasty date from Memphis,⁸ called onyx by the finder, appear from the description (white, red and brown) to be sardonyx. The principal use of these three stones for jewellery was at a late period, from about the Twenty-second Dynasty

¹ Where silica is mentioned as distinct from quartz, this means that the material, although of the same composition as quartz, is not crystalline.

² T. Barron and W. F. Hume, *The Topog. and Geol. of the Eastern Desert of Egypt, Central Portion*, p. 266.

³ xxxvii, 54.

⁴ W. M. Flinders Petrie, *Prehistoric Egypt*, p. 44.

⁵ W. M. Flinders Petrie and J. E. Quibell, *Nagada and Ballas*, pp. 10, 44.

⁶ W. M. Flinders Petrie, G. A. Wainwright and E. Mackay, *The Labyrinth, Gerzeh and Mazghurneh*, p. 22.

⁷ Examples in the Cairo Museum.

⁸ W. M. Flinders Petrie, *Memphis I*, p. 12; Pl. XXVIII (12).

onwards, but more especially during the Greek and Roman epochs. Recently a very fine set of agate vessels, of unknown but probably Roman date, has been found at Qift in Upper Egypt, six of which are in the Cairo Museum¹ and two (the largest) in the hands of a dealer. At a late date agate and onyx beads were imitated in glass.

Amber and other Resins

Although amber and other resins are neither precious nor semi-precious stones, they may conveniently be included here as they were used for amulets and in jewellery in the same manner as these stones.

Petrie mentions two inscribed scarabs that he terms amber² and the large scarab in the pectoral of Hatai of the Twenty-first Dynasty³ and a scarab of uncertain date in the British Museum⁴ are both called amber. That amber may have been used by the ancient Egyptians, especially at a late date, is not denied, but that all the objects termed amber are indeed amber has not been proved, and some at least may well be other kinds of resin, lumps of which are very common in ancient Egyptian graves of all periods, particularly in those of Badarian, predynastic and early dynastic date, and worked resin that is not amber being also known, for example, in the tomb of Tut-ankhamûn,⁵ there was a double finger ring of resin engraved with the royal cartouches ; two large resin scarabs, one having a bird carved in relief on the surface ; a necklace of about fifty-five resin beads graduated from comparatively small ones to very large ones ; a necklace of alternate resin and lapis lazuli beads ; a pair of earrings made up of alternate resin and gold beads ; a broken object (gold mounted) of resin, probably one of a pair of earrings ; a hair-ring of resin ; two knuckle bones of resin and a resin knob of a box. The resin of all these objects is very brittle, dark red by transmitted light and almost black by reflected light ; it is believed not to be amber principally

¹ R. Engelbach, *Annales du Service*, xxxi (1931), pp. 126-7 ; Pl. I.

² W. M. Flinders Petrie, *Scarabs and Cylinders with Names*, p. 9.

³ E. Vernier, *Bijoux et orfèvreries*, Cat. Gén. du Musée du Caire, p. 397.

⁴ H. R. Hall, *Scarabs*, p. 12.

⁵ A. Lucas, in *The Tomb of Tut-ankh-Amen*, II, Howard Carter, p. 184.

on account of its ready solubility in many of the ordinary organic solvents, for example, alcohol and acetone in which amber is almost insoluble. Small resin beads from periods other than the Eighteenth Dynasty are also known and these, too, whenever they have been tested have been found to be easily soluble in alcohol and other organic solvents and, therefore, it is improbable that they should be amber, a characteristic feature of which is its very slight solubility in these solvents.

Pliny quotes Nicias for the statement that amber was produced in Egypt¹ which, however, is not so.

Amethyst

Amethyst consists of translucent quartz coloured by a trace of some compound of manganese : it was largely used in ancient Egypt in the form of beads, chiefly for necklaces, but also for bracelets and was occasionally cut into scarabs : its use dates back to the predynastic period.² From the First Dynasty there are bracelets containing amethyst beads : it was much employed during the Twelfth Dynasty, occasionally during the Empire (for example two amethyst scarabs were found in the tomb of Tut-ankhamûn) and its use continued until Roman times.

Amethyst workings of ancient date exist near Gebel Abu Diyeiba in the Safâga district of the eastern desert,^{3, 4} the stones occurring in cavities in a red granite ; there are also ancient workings about 20 miles south-east of Aswan⁵ and others of Old Kingdom date about 40 miles north-west of Abu Simbel.⁶ Pliny refers to Egyptian amethyst.⁷

Beryl

Beryl may be green, pale blue (aquamarine), yellow or white, but so far as is known, only the green variety occurs in Egypt or was used by the ancient Egyptians.

Beryl occurs in the Sikait-Zubara region of the Red Sea hills,

¹ xxxvii, 11.

² W. M. Flinders Petrie, *Prehistoric Egypt*, p. 44.

³ Mines and Quarries Department, *Report on the Mineral Industry of Egypt*, 1922, pp. 37-9.

⁴ G. W. Murray, in *Cairo Scientific Journal*, viii (1914), p. 179.

⁵ L. Nassim, *Minerals of Economic Interest in the Deserts of Egypt*, in *Congrès Int. de Géog., Le Caire, Avril, 1925*, iii (1926), p. 167.

⁶ O. H. Little, *Annales du Service*, xxxiii (1933), p. 80. ⁷ xxxvii, 40.

where there are extensive old workings,^{1, 2, 3} probably of Græco-Roman date age, and there is not any evidence that the mines were worked in the reign of Amenophis III as stated by Wilkinson.⁴ These mines are mentioned by Strabo⁵ and Pliny⁶ and were probably the original and only source of beryl in classical times. The stones are found in mica-talc schists in the form of hexagonal prisms having characteristic vertical striations. Several attempts have been made in modern times to re-open the mines, all of which have proved commercial failures largely because the stones are not of sufficiently good quality for modern requirements, being often of a pale green colour and full of flaws. Stones of a good enough quality to rank as emeralds (the emerald being only a particularly good quality beryl⁷) may have been found in the past, but none such has been found in modern times. Beryls are always transparent or translucent and never opaque. Beryl, so far as is known to the author, was always used in Egypt in the form of the natural hexagonal crystals in which it occurs, since being slightly harder than quartz the Egyptians were unable to cut it satisfactorily, although it was sometimes bored.

So far as can be ascertained, beryl was never used in ancient Egypt before Ptolemaic times and all the stones of earlier date called beryl that have been examined by the author have been found not to be beryl. Thus the stones in the Dahshûr jewellery called emerald and Egyptian emerald when first described^{8, 9, 10}

¹ Mines and Quarries Department, *Report on the Mineral Industry of Egypt*, 1922, pp. 37-9.

² G. W. Murray, in *Journal of Egyptian Archaeology*, XI (1925), pp. 144-5.

³ W. F. Hume, *Geology of Egypt*, II (Part I), pp. 107-25.

⁴ G. Wilkinson, *The Ancient Egyptians*, II (1890), p. 237.

⁵ *Geography*, XVII, 1, 45.

⁶ XXXVII, 16-18.

⁷ Beryl and emerald have the same composition, both being double silicates of beryllium and aluminium, the only difference between them being one of quality, the deeper coloured and more transparent variety being called emerald and the lighter coloured and less transparent stones being beryl.

⁸ J. de Morgan, *Fouilles à Dabchour, mars-juin, 1894*, pp. 60, 63, 64, 66-70, 112-14.

⁹ J. de Morgan, *Fouilles à Dabchour en 1894-1895*, pp. 51, 53, 58-65.

¹⁰ In several instances Vernier repeats de Morgan's mistake, for example, J. de Morgan, *Fouilles à Dabchour, mars-juin, 1894*, p. 66; Pl. XX (15, 16), and E. Vernier, *Bijoux et orfèvreries*, Cat. Gén. du Musée du Caire, Nos. 52026-7, p. 21.

are green felspar : the stone of Twentieth Dynasty date called an uncut emerald¹ is also green felspar : the beads of Twelfth Dynasty date from Naqada² are most unlikely to be beryl at that period : the three Twelfth Dynasty scarabs³ and one of the two Eighteenth Dynasty scarabs⁴ described as beryl have been examined by the author and are not beryl (the other Eighteenth Dynasty scarab also described as beryl could not be found, but it is very improbable that it is beryl) : the amulets, beads and pendants (predynastic, early dynastic and New Empire) found in Nubia and called beryl^{5, 6} are almost certainly none of them beryl, as some of the beads that were later submitted to the author for verification were olivine. There are large beryls in the silver jewellery recently discovered by Emery at Kostol in Nubia.⁷

Calcite, Iceland Spar

Calcite is simply the geological name for what is termed alabaster in Egypt ; in thin plates it is translucent and in this form it was employed as inlay for jewellery and furniture, for example on some of the objects from the tomb of Tut-ankhamûn.

A very pure and transparent variety of calcite termed 'Iceland spar' was occasionally used for small objects, a cylinder seal of this material from the Sixth Dynasty being known⁸ (though Iceland spar is neither glass-hard nor natural glass as stated in the description), as also beads of the Eighteenth, Twenty-second and Twenty-third Dynasties respectively.⁹ The transparent cover of the small 'ox' pendant from Dahshûr is not Iceland spar (*spath*) as stated by the finder,¹⁰ but rock crystal.

¹ G. Maspero, *Guide to the Cairo Museum*, English trans., 1903, p. 519.

² W. M. Flinders Petrie and J. E. Quibell, *Naqada and Ballas*, p. 45.

³ P. E. Newberry, *Scarab-shaped Seals*, *Cat. Gén. du Musée du Caire*, pp. 353, 354, 356.

⁴ P. E. Newberry, *op. cit.*, pp. 60, 373.

⁵ G. A. Reisner, *Arch. Survey of Nubia, Report for 1907-1908*, pp. 33, 35, 123, 132.

⁶ C. M. Firth, *Arch. Survey of Nubia*, (a) *Report for 1908-1909*, pp. 62, 78 ; (b) *Report for 1909-1910*, pp. 53, 74, 97 ; (c) *Report for 1910-1911*, p. 221.

⁷ Not yet published. ⁸ H. R. Hall, *Cat. of Egyptian Scarabs*, p. xxvi.

⁹ W. M. Flinders Petrie, *Scarabs and Cylinders with Names*, p. 8.

¹⁰ J. de Morgan, *Fouilles à Dahchour en 1894-1895*, p. 67.

All varieties of calcite occur abundantly in the eastern desert of Egypt, Iceland spar being found west of Asyût (from which place there is a fine specimen in the Geological Museum) and also at El-Amârna.

Carnelian, Sard

Carnelian is a translucent red chalcedony, the colour being due to the presence of a small amount of oxide of iron ; in the form of pebbles it occurs abundantly in the eastern desert of Egypt and was much used from predynastic times onwards,¹ at first for beads and amulets and later for inlay for jewellery, furniture and coffins.

In the Eighteenth Dynasty an imitation carnelian consisting of translucent quartz set in a red cement was often employed to supplement the genuine article as inlay, for instance, on two of the coffins of Yuya ; on the coffin formerly supposed to be that of Akhenaten, but now thought to be that of Smenkhkêrê and on several of the objects from the tomb of Tut-ankhamûn, including the mask, the four miniature canopic coffins and the large gold coffin.

Sard is the name applied to the darker varieties of carnelian, some of which are almost black : it was used to a small extent from predynastic times onwards.² Pliny states ³ that sard occurs in Egypt, which is probably so.

Chalcedony

Chalcedony is a form of silica, translucent and somewhat waxy in appearance and, when pure, white or greyish-white in colour with often a slight bluish tint : it may, however, be of almost any colour owing to the presence of a small proportion of impurity, many of the coloured varieties having special names.

Chalcedony occurs in Egypt near Wâdi Saga ⁴ and in Wâdi Abu Gerîda ⁴ in the eastern desert ; in the Baharia Oasis of

¹ W. M. Flinders Petrie, *Prehistoric Egypt*, p. 44.

² W. M. Flinders Petrie, G. A. Wainwright and E. Mackay, *The Labyrinth, Gerzeh and Mazghurneh*, p. 22.

³ xxxvii, 31.

⁴ T. Barron and W. F. Hume, *Top. and Geol. of the Eastern Desert of Egypt, Central Portion*, p. 266.

the western desert¹ ; about 40 miles north-west of Abu Simbel² and in the Fayûm province.¹ It was occasionally employed in ancient Egypt for beads, pendants, and scarabs, its use dating back to predynastic times.³

Coral

Coral consists of the hard skeletons of various marine organisms and it may be white, various shades of red, or black in colour. Only the white and red kinds need be considered, as there is not any record of the black variety having been used anciently, although it occurs in the Red Sea.

Only one instance of the ordinary white coral having been used in ancient Egypt can be traced, which was at Defenneh (seventh to sixth century B.C.) where Petrie discovered a large quantity in the form of natural branches.⁴

There are two varieties of red coral, one the well known, solid, branching kind (*Corallium nobile* ; *Corallium rubrum*) used at the present day for jewellery, especially for necklaces, and the other the lesser known 'pipe' or 'organ' coral (*Tubipora musica*), which, as the name indicates, occurs in the form of hollow tubes, the appearance of which is somewhat suggestive of miniature organ pipes.

The former, or precious coral, is mainly obtained from the western Mediterranean and was an important article of commerce in Roman times. All the examples known from ancient Egypt are of late date, ranging chiefly from the Ptolemaic to the Coptic period and they consist either of amulets, or more generally, of beads or small branched pieces bored for suspension round the neck. Beads of this coral are common in the graves of late date recently discovered by Emery at Kostol, near Abu Simbel in Nubia.⁵

Pipe coral occurs on the shores of the Red Sea ; Pococke saw

¹ Specimens from these sources may be seen in the Geological Museum, Cairo.

² O. H. Little, *Annales du Service*, xxxiii (1933), p. 80.

³ W. M. Flinders Petrie, G. A. Wainwright and E. Mackay, *The Labyrinth, Gerzeh and Mazghurneh*, p. 22.

⁴ W. M. Flinders Petrie, *Nebesheb and Defenneh*, p. 75.

⁵ Not yet published.

it at Tor (Sinai¹) and in the Geological Museum at Cairo there is a specimen from Dahab (East Sinai), but it is also found farther south.² This coral was known and used anciently, and beads of it, both of Badarian and early predynastic date, have been found³ and also pieces broken up ready for threading⁴; it has been found, too, in a Nubian grave of about Old Kingdom date⁵ and also in an Eighteenth Dynasty house at El-Amârna.⁶

In addition to the specimens enumerated, other examples of coral are known, of which neither the kind nor colour are mentioned, for instance, a pierced branched piece of Badarian age⁷; a specimen of predynastic date⁸; a lump of 'fossil coral'⁹ and a 'large piece.'¹⁰

Green Felspar

Green felspar (microcline) or Amazon stone, as it is sometimes called, is an opaque pale green stone, not very uniform in colour, consisting of a double silicate of aluminium and potassium. It has been found in Egypt, in small quantity, at Gebel Migif in the eastern desert¹¹ and it seems likely that there may be more in the neighbourhood that has not yet been discovered: the source of the ancient supply is not known.

Green felspar was employed on a small scale for beads from as early as the neolithic period¹² and was much used in the

¹ R. Pococke, *A Description of the East and some other Countries*, p. 141.

² T. Barron and W. F. Hume, *op. cit.*, p. 137.

³ G. Brunton and G. Caton-Thompson, *The Badarian Civilisation*, pp. 38, 56. This material, which is now in the Cairo Museum, is organ coral and not dentalium as reported by the specialist to whom it was submitted by the finder.

⁴ W. M. Flinders Petrie and J. E. Quibell, *Naqada and Ballas*, p. 21.

⁵ G. A. Reisner, *Arch. Survey of Nubia, Report for 1907-1908*, p. 42. These beads are described as 'shell or coral' and the colour is not stated, but the late Mr. C. M. Firth informed the author that the material was pale red pipe coral.

⁶ T. E. Peet and C. L. Woolley, *The City of Akhenaten*, I, p. 21.

⁷ G. Brunton and G. Caton-Thompson, *op. cit.*, p. 35. ⁸ *Id.*, pp. 56, 63.

⁹ G. Brunton, *Qau and Badari I*, p. 26.

¹⁰ A. C. Mace, *Egyptian Expedition, 1920-1921*, in *Bull. Met. Mus. of Art*, New York, II (1921), p. 12.

¹¹ J. Ball, *The Geog. and Geol. of South-Eastern Egypt*, p. 272.

¹² G. Caton-Thompson, *The Neolithic Industry of the Northern Fayum Desert*, in *Journal Royal Anthropol. Inst.*, LVI (1926), p. 313.

Twelfth Dynasty, for example, in the jewellery from Dahshûr and El-Lahûn respectively, in the description of the former of which it is wrongly termed emerald: it was also used during the Empire, for instance, for amulets and inlay in the tomb of Tut-ankhamûn.

Green felspar is frequently confused with other green stones and is sometimes called 'mother of emerald,' though it has no connexion whatever with emerald or beryl. Not infrequently this stone has a bluish tint and sometimes is definitely blue.

Garnet

Garnet is the name applied to a group of minerals, consisting of double silicates of certain metals, that are widely distributed in nature, but are generally too dull for use as gem stones. The garnet employed by the ancient Egyptians was a dark red or reddish-brown translucent stone that occurs plentifully in the country, namely, at Aswan, in the eastern desert¹ and in Sinai,² the stones, however, usually being too small for use, especially those from Aswan, the largest being those from western Sinai. Garnet was used for beads as early as pre-dynastic times.³

Hæmatite

Hæmatite is an oxide of iron much used as an ore for the production of the metal: it occurs in different forms and colours and may be black, red, brown or foliated and micaceous. An earthy kind also occurs, but it will save confusion if this latter is called by the better name of red ochre. The particular hæmatite used by the ancient Egyptians for beads, amulets, *kohl* sticks and small ornaments was a black opaque kind with a metallic lustre, which was employed as early as the pre-dynastic period.⁴

Although hæmatite occurs plentifully in Egypt and although it was worked in the eastern desert at a late period (probably

¹ T. Barron and W. F. Hume, *op. cit.*, pp. 170, 218.

² T. Barron, *The Topog. and Geol. of the Peninsula of Sinai (Western Portion)*, p. 203.

³ W. M. Flinders Petrie, *Prehistoric Egypt*, p. 44.

⁴ W. M. Flinders Petrie, *op. cit.*, p. 43.

Roman) for the production of metallic iron,¹ it is not known from where the small amount was obtained that was used earlier.

Jade

The term jade includes two distinct minerals, nephrite or true jade and jadeite, which are so much alike that unless examined chemically or microscopically they cannot be distinguished with certainty from one another. Both may be coloured white, grey or various shades of green and both are translucent with a somewhat waxy or greasy lustre. The specific gravity and hardness are also much alike and may overlap, jadeite, however, being slightly the harder and heavier of the two. Chemically, the composition of the two materials is very different, nephrite being essentially a double silicate of calcium and magnesium and jadeite a double silicate of aluminium and sodium.

Nephrite occurs in the valley of the Kara Kash river in the Kwen Luen Mountains north of Kashmir and other localities in the neighbourhood, where there are old workings that are now almost exhausted; in Siberia, west of Lake Baikal and in New Zealand. Jadeite, so far as is known, is found only in Upper Burma.

Several specimens of what may be nephrite or jadeite have been found in Egypt, for example, two axe-heads of predynastic date, one of which is in the Cairo Museum² and the other in the Museum of University College, London, where there is also a heart scarab of Nineteenth Dynasty date³; also a small axe-head recently discovered by Junker at the neolithic settlement of Merimde-Benisalâme and now in the Cairo Museum, which the finder calls 'nephrit (chloromelanit)'⁴; a double signet ring found in the tomb of Tut-ankhamûn⁵ and several other objects stated to be possibly jade,² which latter in the author's opinion

¹ See p. 198.

² J. E. Quibell, *Archaic Objects*, in *Cat. Gén. du Musée du Caire*, pp. 235-6.

³ W. M. Flinders Petrie, *Scarabs and Cylinders with Names*, pp. 8, 89.

⁴ H. Junker, *Merimde-Benisalâme von 7 Februar bis 8 April 1930*, p. 80; Pl. VII.

⁵ A. Lucas, *Appendix II*, in *The Tomb of Tut-ankh-Amen*, III, Howard Carter, p. 182.

are neither nephrite nor jadeite. As it was impossible to examine any of these objects either chemically or microscopically without destroying them, the only determination that could be made was that of the specific gravity, which was done for the axe-heads and ring with the following results, namely, neolithic axe-head, 3.35; Cairo predynastic axe-head, 2.98; ring 3.04,¹ from which it seems probable that the neolithic axe-head may be jadeite and the predynastic axe-head and ring may be nephrite.

Jasper

Jasper is an impure, opaque, compact variety of silica, that may be coloured red, green, brown, black or yellow by compounds of iron, the red being the kind principally used in ancient Egypt, though the other colours were occasionally employed.

Red jasper was used chiefly for beads and amulets, though sometimes as inlay for jewellery, and occasionally for scarabs and other purposes, and parts of two shallow bowls of red jasper from the First Dynasty are known²: its use dates back to predynastic times.³ Green jasper (for beads) is known from as early as the Fourth Dynasty⁴: brown and black jasper date back to the Middle Kingdom, from which period there are several scarabs of these stones⁵: yellow jasper, so far as is known, was not used before the Eighteenth Dynasty, the best example being the well known broken head or face of Nefretiti.

The recognition of red and yellow jaspers presents no difficulty, but in the case of green, brown and black jaspers mistakes of identification are not uncommon and statements about their use need verification before they can be accepted.

The jaspers of Egypt are well known and specimens of a brown jasper (sometimes banded) are exhibited in mineral

¹ A. Lucas, Appendix II, p. 182, in *The Tomb of Tut-ankh-Amen*, III, Howard Carter, where the specific gravity is stated to be 3.4 instead of 3.04, which caused it to be classed as jadeite instead of nephrite, which it probably is.

² J. E. Quibell, *Excavations at Saqqara (1912-1914)*, pp. 16, 17; Pl. XII. Mr. Quibell kindly showed the author part of a second similar bowl.

³ R. Engelbach, *Harageh*, p. 14.

⁴ G. Brunton, *Qau and Badari II*, p. 20.

⁵ W. M. Flinders Petrie, *Scarabs and Cylinders with Names*, p. 8.

collections in London, Vienna and Prague and possibly elsewhere. Red jasper occurs as bands in certain rocks in several localities in the eastern desert, for example in the neighbourhood of the Hadrabia hills¹: near Wâdi Saga¹ and in Wâdi Abu Gerîda¹ in some of which places there is evidence of ancient mining: brown jasper is found plentifully in the form of pebbles: a large vein of green jasper spotted with red, which had been worked anciently, was seen by Bruce on his journey from Qena to Quseir²: whether black jasper is found naturally in Egypt cannot be stated, but no record of its occurrence can be traced: yellow jasper, so far as is known, does not occur in Egypt, but is found in the neighbourhood of Smyrna in Asia Minor and also in Sicily.

Lapis Lazuli

Lapis lazuli is an opaque stone of a dark blue colour with often spots, patches or veins of white (calcite) and sometimes minute yellow spangles of iron pyrites, looking like specks of gold: chemically, lapis lazuli consists of silicates of aluminium and sodium together with sodium sulphide: it is certainly the *sapphiros* of Theophrastus³ and Pliny.⁴

So far as is known, lapis lazuli does not occur in Egypt, though several statements that it does occur have been made; thus MacIver says⁵ that 'lapis lazuli is known to be native of Egypt,' but no evidence for this is given and the value of the statement is much discounted by the further statement that garnets are not found in Egypt, whereas they occur plentifully. Idrissi mentions⁶ a mine of lapis lazuli near Kharga Oasis, but no confirmation can be obtained for any such occurrence.

The chief source of lapis lazuli is Badakshan in the north-east corner of Afghanistan. These mines are referred to by Marco Polo in the thirteenth century⁷ and were probably the original source of the material. Although it is frequently stated

¹ T. Barron and W. F. Hume, *op. cit.*, pp. 52, 221, 228, 266.

² J. Bruce, *Travels to Discover the Source of the Nile*, II, 2nd ed., 1805, p. 85.

³ *History of Stones*, XLIII. ⁴ xxxvii, 39.

⁵ D. Randall MacIver and A. C. Mace, *El Amrah and Abydos*, pp. 48-9.

⁶ *Geography*, French trans. by P. Amédée, I, Paris, 1836, p. 122.

⁷ *The Travels of Marco Polo the Venetian*, p. 84 (Everyman's Library).

that lapis lazuli was mined anciently in Persia, no confirmation of this can be obtained and the rumour may be due to a confusion between lapis lazuli and turquoise, the latter of which does occur in that country, or to the fact that the lapis lazuli trade passed through Persia or was in the hands of Persian merchants.

Lapis lazuli was used in ancient Egypt from predynastic times¹ onwards for beads, amulets, scarabs and other small objects as well as for inlay in jewellery, for which purpose it was extensively employed during both the Middle Kingdom and the Empire.

The use of lapis lazuli is frequently mentioned in the ancient Egyptian records, but so far as can be ascertained not earlier than the Twelfth Dynasty.² In the Eighteenth Dynasty lapis lazuli is stated to have been obtained from Assur,³ Isy,⁴ Retenu,⁵ Shinar,⁶ Syria⁷ and Zahi⁸ and in the Nineteenth Dynasty from God's Land⁹ and Naharin,¹⁰ all in western Asia. In both the Nineteenth¹¹ and Twentieth Dynasties¹² lapis lazuli of Tefrer, an unknown country, is mentioned.

In the Eighteenth Dynasty lapis lazuli was much imitated for inlay by means of a dark blue opaque glass, for example on two of the coffins of Yuya : on the coffin now thought to be that of Smenkhkêrê and on the mask, the four miniature canopic coffins, two of the large coffins and on other objects from the tomb of Tut-ankhamûn.

Malachite

Malachite is a copper ore of a fine green colour, a fractured surface of which often displays a beautiful and characteristic zonary structure, the successive layers showing strata of alternating light and dark tints : chemically it consists of hydrated (basic) carbonate of copper.

Although malachite is very common in ancient Egyptian

¹ W. M. Flinders Petrie, *Prehistoric Egypt*, p. 44. Also a tube of this material of unknown use mounted in gold in the Cairo Museum, No. J. 31340.

² J. H. Breasted, *op. cit.*, I, 534, 667, 668. ³ II, 446.

⁴ II, 493.

⁵ II, 447.

⁶ II, 484.

⁷ II, 509, 518, 536.

⁸ II, 459, 462.

⁹ III, 116.

¹⁰ III, 434.

¹¹ III, 448.

¹² IV, 30.

graves of all periods from the Badarian and predynastic to certainly as late as the Nineteenth Dynasty,¹ the principal and almost the only forms in which it is found is that of powder (either loose or slightly cohering together) for use as an eye-paint, as lumps of the raw material from which the powder was made, or as stains on palettes and stones on which the powder was ground, and it is only very rarely indeed that malachite has been discovered either as worked objects or as inlay in jewellery. The few instances of this use of malachite that can be traced are as follows: a few large roughly made beads of predynastic date from Girga,² some beads from Ballâs of the same period,³ one or two small scorpions of the archaic period,⁴ two pieces cut for ornament of the First Dynasty,⁵ a few beads⁶ and a tiny broken worked fragment from the Eighteenth Dynasty (the tomb of Tut-ankhamûn), a small animal-shaped amulet of archaic form from the Nineteenth Dynasty⁷ and a scarab of unknown date.⁸

Malachite has frequently been confused with other green stones, such as green turquoise, green felspar and even with beryl. Thus, although the necklace of Twelfth Dynasty date from Dahshûr in the Cairo Museum, stated⁹ to have lozenge-shaped plaques of malachite, cannot be identified with certainty, no necklace of any date with malachite on it can be found in the Museum. There are, however, two necklaces from Dahshûr that answer to the general description of the one referred to, both of which have lozenge-shaped plaques, but in one case the green stone is green felspar and in the other it is turquoise. The beads in the collar and the stones in the bracelet, both of

¹ A. Lucas, *Cosmetics, Perfumes and Incense in Ancient Egypt*, in *Journal, Egyptian Archaeology*, XVI (1930), pp. 41-4.

² In the Cairo Museum, No. J. 44488.

³ W. M. Flinders Petrie and J. E. Quibell, *Nagada and Ballas*, p. 10.

⁴ J. E. Quibell and W. F. Green, *Hierakonpolis*, II, p. 38. In *Hierakonpolis*, I, Petrie says (p. 8) that one of the scorpions is of black hæmatite.

⁵ W. M. Flinders Petrie, *The Royal Tombs of the Earliest Dynasties*, II, p. 37; Pl. XXXV.

⁶ A. Lucas, in *The Tomb of Tut-ankh-Amen*, H. Carter, II, Appendix II, p. 185.

⁷ The Egyptian Exploration Society, *Catalogue of Exhibits*, 1926, p. 12. Examined by the author.

⁸ W. M. Flinders Petrie, *Scarabs and Cylinders with Names*, p. 8.

⁹ G. Maspero, *Guide to the Cairo Museum*, English trans., 1903, p. 511.

Græco-Roman age, stated by Maspero¹ to be malachite and, in the case of the bracelet, also thought by Vernier² possibly to be malachite, are beryl, the bizarre shape of the stones commented upon by Vernier being simply the natural hexagonal form of the beryl crystal as found, the Egyptians apparently not having any means of cutting this stone, which is slightly harder than quartz, though they were able to bore it.

Malachite occurs in Sinai and in the eastern desert of Egypt,³ from both of which places it was obtained anciently, at first probably merely from surface outcrops for use as an eye-paint and later by mining for the production of copper.

From two of the same localities in Sinai where copper ore occurs, namely Maghâra and Serabât el-Khâdim, turquoise was also obtained anciently⁴ and this occurrence in the same place of two different materials, one (malachite) green and the other (turquoise), though often blue, frequently greenish-blue or even definitely green, has given rise to considerable confusion, so much so that malachite has been termed turquoise matrix, though the two materials are totally different in composition and have no connexion with one another. It has also resulted in the ancient Egyptian name for turquoise (*mafkat*) being translated as malachite,⁵ which if accepted, would mean that malachite was associated with silver, gold and costly stones; particularly lapis lazuli, and was used plentifully for finger rings, collars, inlay and scarabs and that there was no mention of turquoise, whereas the Egyptian objects in the various museums prove the contrary, namely, that it was turquoise that was largely used in jewellery (particularly with lapis lazuli), for inlay and for scarabs and not malachite, which was very rarely employed as a gem stone.

Pearl

Pearls are calcareous concretions of peculiar and characteristic lustre produced by various molluscs, chiefly, however, by the

¹ G. Maspero, *op. cit.*, p. 527.

² E. Vernier, *op. cit.*, p. 64, No. 52051, Pl. XVI.

³ A. Lucas, *Copper in Ancient Egypt*, in *Journal, Egyptian Archaeology*, XIII (1927), pp. 162-5.

⁴ See pp. 156-7.

⁵ J. H. Breasted, *op. cit.*, v (Index), p. 143.

pearl-oyster and the pearl-mussel, the former of which is found on the Red Sea coast of Egypt, as well as in the Persian Gulf, off the coast of Ceylon and in other localities.

Although mother-of-pearl was used in Egypt from predynastic times, the pearl was not employed until the Ptolemaic period. To this only one exception is known to the author and that not of true pearls, namely the button pearls in the necklace of Queen Ah-hotpe, mother of King Amôsis of the beginning of the Eighteenth Dynasty.¹

Olivine, Peridot

Olivine is a compound silicate of magnesium and iron : it is transparent or translucent and usually of a pale green colour : it was employed in Egypt as early as predynastic times for beads,^{2, 3 4} and it is this stone that Petrie calls 'noble serpentine.' As already stated⁵ some and probably most of the beads and other objects found in Nubia and termed beryl are olivine.

Peridot, a transparent pale green stone, is merely the gem form of olivine ; it is found on St. John's Island in the Red Sea and is possibly the stone that Strabo⁶ and Pliny⁷ call *topazos*, as both writers state that this was obtained from such a locality : Strabo refers to the golden lustre of the stone, but Pliny states that it was leek-green and mentions its softness compared to other gem stones.

The only example of the use of peridot in ancient Egypt of which any record can be found is that of a scarab of the Eighteenth Dynasty,⁸ though the olivine beads may have been made from peridots.

¹ A. Lucas, *The Necklace of Queen Aahhotep*, in *Annales du Service*, xxvii (1927), pp. 69-71.

² W. M. Flinders Petrie and J. E. Quibell, *Nagada and Ballas*, p. 44.

³ In describing certain objects from Abydos, Petrie says (*The Royal Tombs of the Earliest Dynasties*, II, p. 37) 'a piece of the clear green serpentine which is frequent in prehistoric work.'

⁴ G. Brunton and G. Caton-Thompson, *The Badarian Civilisation*, p. 56.

⁵ See p. 340.

⁶ XVI, 4, 6.

⁷ VI, 34 ; xxxvii, 32.

⁸ W. M. Flinders Petrie, *Scarabs and Cylinders with Names*, p. 8.

Quartz, Rock Crystal

Quartz is a crystalline form of silica which when pure is colourless and transparent, but which may be translucent or opaque. The former is termed rock crystal and the latter milky or cloudy quartz, the milkiness being due to multitudes of small air cavities. Sometimes quartz is coloured from light brown to almost black and is then termed smoky quartz, which particular kind has been found in an ancient gold mine at Romit in the eastern desert.¹

Quartz occurs abundantly as veins in igneous rocks in the eastern desert² and at Aswan,³ at which latter place an outcrop of quartz is shown to tourists as alabaster. This has been worked anciently to some extent and a few blocks of it may be seen at the north end of the island of Philae.³

Rock crystal was employed in ancient Egypt in small amount from predynastic times onwards,⁴ being fashioned into beads and other objects including small vases and the cornea of eyes in statues and on coffins. In the Eighteenth Dynasty, as already mentioned,⁵ it was employed as inlay, being set in red cement to imitate carnelian and in this same dynasty the handle of the iron dagger from the tomb of Tut-ankhamûn is ornamented with a finely-worked knob of rock crystal,⁶ which, however, is probably not of Egyptian origin. In the Cairo Museum there are a number of large implements of opaque quartz (possibly of paleolithic date) from Aswan, as also a number of small triangular-shaped implements and a broken implement with serrated edges of clear rock crystal, all of early date.

All varieties of quartz are much harder than glass, which they scratch easily, and they are also harder than steel, and, therefore, they cannot be marked with a file.

Turquoise

Turquoise consists of hydrated phosphate of aluminium coloured by means of a trace of a copper compound; it is

¹ J. Ball, *The Geog. and Geol. of South-Eastern Egypt*, p. 353.

² T. Barron and W. F. Hume, *op. cit.*, pp. 218, 221.

³ J. Ball, *The Aswan Cataract*, p. 84.

⁴ W. M. Flinders Petrie, *Prehistoric Egypt*, p. 44.

⁵ See p. 341. ⁶ Howard Carter, *The Tomb of Tut-ankh-Amen*, II, p. 135.

never crystalline, but occurs in opaque amorphous masses filling veins in the mother rock: the typical colour is a delicate sky-blue, though many stones are greenish-blue and others definitely green.

The source of turquoise employed in ancient Egypt was undoubtedly Sinai at Wâdi Maghâra and Serabât el-Khâdim, in both of which places there are ancient workings, the former of which are still exploited unsystematically and intermittently by the local bedouin.^{1, 2, 3, 4} The turquoise occurs in seams in a sandstone rock. Another ancient and well known source of turquoise was Persia.

Turquoise has been known and used in Egypt from both the Badarian⁵ and predynastic⁶ periods respectively: its authenticity has been doubted in the case of several bracelets of First Dynasty date from Abydos⁷ in which it is present and it has been thought to be glass,⁸ though it is undoubtedly turquoise as originally described by the finder, much of it, however, being green and not blue: it was employed as inlay in a number of anklets found by Reisner in the Fourth Dynasty tomb of Hetepheres at Giza, where it was at first described as malachite⁹: it occurs plentifully in the Twelfth Dynasty jewellery from Dahshûr, where some examples have been thought to be artificial on account of their excellent colour¹⁰: it is also present in small amount in the jewellery from the tomb of Tut-ankhamûn, namely as a scarab of a good blue colour and as greenish-blue inlay on two pectorals.

On two of the coffins of Yuya, on the coffin now thought

¹ Mines and Quarries Department, *Report on the Mineral Industry of Egypt*, 1922, p. 38.

² J. Ball, *The Geog. and Geol. of West-Central Sinai*, pp. 11, 163.

³ T. Barron, *The Topog. and Geol. of the Peninsula of Sinai (Western Portion)*, pp. 209-12.

⁴ G. W. Murray, *The Hamada Country*, in *Cairo, Sci. Journ.*, vi (1912), pp. 264-73.

⁵ G. Brunton and G. Caton-Thompson, *op. cit.*, pp. 27, 41, 56. See p. 166, n. 4.

⁶ W. M. Flinders Petrie, *Prehistoric Egypt*, p. 44.

⁷ W. M. Flinders Petrie, *The Royal Tombs of the Earliest Dynasties*, II, pp. 17-19.

⁸ E. Vernier, *op. cit.*, pp. 10-11, 13-14.

⁹ See note 7, p. 204.

¹⁰ E. Vernier, *op. cit.*, pp. 88, 298, 299, 307, 336.

to be that of Smenkhkerê, on the miniature canopic coffins, on the mask, and on two of the large coffins of Tut-ankhamûn, turquoise is extensively imitated in opaque blue glass, as also for a full-size head-rest, a large writing palette and two models of persea fruit.

As already pointed out,¹ Breasted's translation of the ancient Egyptian records makes no mention whatever of turquoise, which, considering the extensive and early use of this material, is remarkable and is due to the ancient Egyptian word for turquoise (*mafkat*)^{2, 3} having been translated malachite.

¹ See p. 350.

² A. H. Gardiner, *Egyptian Grammar*, p. 543.

³ V. Loret, *La turquoise chez les anciens Égyptiens*, in *Kémi*, I (1928), pp. 99-114.

CHAPTER XIII

STONES OTHER THAN BUILDING STONES AND PRECIOUS STONES

Certain stones have already been discussed in connexion with building materials, but stone was employed in ancient Egypt, not only for building, but also for obelisks, sarcophagi, statues and other monuments, as well as for smaller objects, such as statuettes, bowls, vases, tools and weapons and the earliest objects that have survived to the present day in Egypt, as in many other countries, are of stone (flint). The stones employed, excluding precious and semi-precious stones, which have been dealt with separately, comprise alabaster, basalt, breccia, calcium sulphate (including gypsum and anhydrite), diorite, dolerite flint (including chert), granite, limestone, marble, obsidian, porphyry and porphyritic rocks, quartzite, rock crystal, sandstone, schist, serpentine, slate, steatite and tuff (volcanic ash) and few countries possess such a variety of stones as Egypt, many of them being very handsome when cut and polished.

There are few subjects in Egyptology that are so full of confusion, and even of contradiction, as that of the nomenclature of the various kinds of stone employed by the ancient Egyptians and the author proposes to try and unravel the tangle to at least some extent. It is realised that in any scheme of classification there must be difficulties and anomalies and that it is practically impossible to frame definitions that will be satisfactory from every point of view, and the final court of appeal must of course be the petrologist, but it is thought that guided by a few broad principles, with which it is hoped every one will be in agreement, the matter may be much simplified. The principles are, first, that for the purposes of Egyptology any highly technical description of the various rocks is un-

necessary and that general features and broad characteristics alone need be taken into account, and hence that many of the finer distinctions of the geologist may be disregarded, and second, that old names that are well rooted in the literature of Egyptology should be retained whenever possible, unless seriously wrong.

Alabaster

The nature and occurrence of alabaster have already been dealt with in connexion with its use as a building material¹ and, therefore, need not again be discussed. This stone was always a favourite with the ancient Egyptians, doubtless partly owing to the fact that it not only looked well and took a good polish, but also because, being a soft stone, it was easy to work.

In addition to its employment as a building material, alabaster was used for many other purposes, and objects of this stone are known that range in date from predynastic times to a very late period, one of its commonest and earliest uses being for making vases and another early, but occasional, use being for mace-heads; it was also employed for sarcophagi (for example those of Hetepheres and Seti I respectively), canopic boxes, canopic jars, statues, statuettes, offering-tables, bowls, dishes and other objects.

Basalt

Basalt and its occurrence in Egypt have been treated of in detail, both in the present book in relation to its use as a building material² and also elsewhere,³ and, therefore, need not further be described; but long before it was employed for building and despite its hardness and the consequent difficulty of working it, this stone was used for making vases, some of which date back to neolithic times⁴ and others to the Badarian⁵ and predynastic^{5, 6}

¹ See p. 56.

² See p. 59.

³ A. Lucas, *Egyptian Predynastic Stone Vessels*, in *Journal of Egyptian Archaeology*, xvi (1930), pp. 203-5.

⁴ In a private communication Miss Caton-Thompson states that 'the neolithic Fayumis were using local basalt for stone vases as well as axes.'

⁵ G. Brunton and G. Caton-Thompson, *The Badarian Civilisation*, pp. 5, 7, 28, 41, 57.

⁶ A. Lucas, *op. cit.*, p. 201.

periods respectively. Axe-heads of basalt of neolithic date are also known.¹

One occasional use of basalt in the early dynastic period was for sarcophagi (though every sarcophagus called basalt is not basalt), for example the sarcophagus found by Vyse in the pyramid of Mycerinus (which was lost at sea on its way to England, but of which a small piece was sent to the British Museum²) is stated to have been of basalt,² though 'the brittle quality of the stone'³ referred to by Vyse is not easy to understand. A small piece of stone exhibited at the British Museum with the wooden coffin from the pyramid of Mycerinus, as seen through the glass of the case appears to be basalt, and this may be the piece referred to, though pieces of two different sarcophagi, both called basalt, were sent by Vyse to the British Museum.⁴ Other sarcophagi, however, were stated by Vyse to be basalt, one, at least, of which is certainly not basalt, but light blue-grey schist. Thus Vyse found a number of sarcophagi in Campbell's tomb at Giza, three of which he calls basalt,⁵ and in the British Museum (No. 1384) there is a blue-grey schist sarcophagus labelled 'Grey basalt coffin of Wah-Ab-Ra' and stated to be of the Twenty-sixth Dynasty from Campbell's tomb.

In addition to the use of basalt for sarcophagi it was also occasionally employed for statues, though on account of the frequent confusion of basalt with dark-grey granite, black granite and schist, objects have frequently been called basalt that are not basalt.

Breccia

Breccia is composed of angular fragments of one or more kinds of rock embedded in a matrix of another material, the characteristic feature being that the included fragments are sharp-edged and unworn, as distinguished from the worn and rounded fragments of a conglomerate. The name breccia,

¹ See n. 4, opposite.

² H. Vyse, *The Pyramids of Gizeh*, II, p. 84, and n. 4.

³ H. Vyse, *op. cit.*, I, p. xviii. ⁴ H. Vyse, *op. cit.*, I, pp. 214-15, n. 3.

⁵ One found under the red granite sarcophagus Y; one marked X and one marked B. (H. Vyse, *op. cit.*, II, pp. 131, 132; Figs. 2 and 3.)

therefore, denotes the structure of the rock and not its composition. A number of different breccias occur in Egypt and were used anciently, of which two may specially be mentioned, namely, a red and white variety and a green variety.

The red and white breccia is calcareous and consists of white fragments embedded in a red matrix ; it is found abundantly on the west bank of the Nile in several localities, for instance, north of Minya,¹ near Asyût,¹ at Thebes¹ and near Esna¹ and it also occurs in the eastern desert.² This stone was used in predynastic and early dynastic times chiefly for vases³ and apparently not again until the Romans worked it for exportation to Italy.

The green breccia consists of fragments of rocks of the most varied description embedded in a matrix, which is variable in colour with green predominating ; it is, however, not a typical breccia, as while some of the fragments are angular, others are rounded, and it is sometimes called a brecciated conglomerate ; but since in the past it has always been termed breccia and was the *breccia verde antico* of the Romans, it is much better to retain the old name.

This green breccia is found in several localities, the best known of which is the Wâdi Hammamât in the eastern desert on the Qena-Quseir road,^{4, 5} where it occurs extensively and where it was worked anciently, though so far as is known, not until a very late period ; it is not, however, the typical rock of the Wâdi, as is often stated, this being schist. Green breccia occurs too at the mouth of the Wâdi Dib⁴ ; in the region to the west of Gebels Dara and Mongul in the El-Urf chain⁴ and at Gebel Hamata,⁶ all of which are situated in the eastern desert and also in Sinai.⁷

The green breccia of the Wâdi Hammamât was used occasion-

¹ W. F. Hume, *Explan. Notes to Geol. Map of Egypt*, p. 46.

² T. Barron and W. F. Hume, *The Topog. and Geol. of the Eastern Desert of Egypt, Central Portion*, p. 171.

³ For references, see A. Lucas, *Journal of Egyptian Archaeology*, xvi (1930), p. 201.

⁴ T. Barron and W. F. Hume, *op. cit.*, p. 263.

⁵ W. F. Hume, *Geology of Egypt*, II (Part I), pp. 256-60.

⁶ J. Ball, *The Geog. and Geol. of South-Eastern Egypt*, p. 351.

⁷ W. F. Hume, *Explan. Notes to Geol. Map of Egypt*, p. 49.

ally in Egypt at a late period, but it was quarried chiefly by the Romans for export to Italy. The principal and probably the only objects of this breccia in the Cairo Museum are parts of a broken sarcophagus of Nectanebo II (Thirtieth Dynasty) and in the British Museum there is a similar sarcophagus of the same pharaoh. Legrain described¹ a number of statues from Karnak as being of green breccia, but those that the author has been able to examine are not green breccia.

A small grinding stone for ink in the Cairo Museum (No. 46145), though of green breccia, is not that from Wâdi Hammamât, but that from Gebel Hamata, the stone consisting of black, angular fragments embedded in a dark green ground mass, and is identical with a specimen in the Geological Museum (No. 10407) and with the coloured illustration of a type specimen in the geological report.²

Fragments of breccia of foreign origin, probably from Greece, have been found in excavations at Alexandria.

Diorite

Diorite is the name of a family of crystalline, granular rocks consisting essentially of felspar (white) and hornblende (black or dark green), which may be either fine-grained or coarse-grained. It occurs extensively in Egypt in several localities, namely, near Aswan, in the eastern and western deserts and in Sinai.³

The use of diorite in Egypt goes back to neolithic times, from which period there is a broken object (possibly part of a palette) and an axe-head.⁴

The diorite employed anciently was of several different kinds. One of these, a coarse-grained black and white speckled rock in which the component minerals (white felspar and black hornblende) are fairly evenly distributed, was used in pre-dynastic and early dynastic times for maceheads, bowls and

¹ G. Legrain, *Statues et Statuettes, Cat. Gén. du Musée du Caire*, I, pp. 1, 41; II, pp. 3, 36, 89, 98.

² J. Ball, *The Geog. and Geol. of South-Eastern Egypt*, p. 351; Pl. XXV.

³ For references, see A. Lucas, *Journal Egyptian Archaeology*, XVI (1930), p. 202.

⁴ G. Caton-Thompson, *Journal Royal Anthropol. Inst.*, LVI (1926), pp. 313; Pl. XXXV (3).

vases and occasionally for palettes.¹ This particular variety was probably obtained from Aswan, where an identical rock is known to occur² and where another rock, granite, was being worked at an early date and, although a similar diorite is largely developed in the eastern desert in the hills north of the Qena-Quseir road and was worked in Wâdi Semna (north-west of Quseir) by the Romans,³ there is not any evidence of earlier working.

Another kind of rock that is called diorite by archæologists (the name being well rooted in the literature) is that of which the well known statue of Chephren in the Cairo Museum is made, the use of which is not known before the early dynastic period and is principally confined to the Old Kingdom. This rock, which is banded, or mottled, black and white, varies considerably in appearance, even in different parts of the same block, and the general effect may be dark grey, light grey or white slightly flecked with black, the last-named variant having been much employed for making bowls and vases, the other varieties having been used for statues, especially during the Fourth Dynasty.

Some years ago, the author suggested⁴ that, since this rock has a gneissic structure, a suitable name for it would be diorite-gneiss, which would indicate, both its composition and structure, and Mr. O. H. Little, Director of the Geological Survey of Egypt, in a recent description of it states,⁵ 'If diorite-gneiss were substituted for diorite, it would be more correct, though the term is not applicable to all varieties.'

In the past there has been much speculation respecting the locality from which this particular diorite-gneiss was obtained, which was unknown until very recently, when the source was discovered in the western desert about 40 miles north-west of Abu-

¹ For references, see A. Lucas, *Journal Egyptian Archaeology*, xvi, (1930), p. 202.

² J. Ball, *The Aswan Cataract*, Pl. V (2).

³ T. Barron and W. F. Hume, *The Topog. and Geol. of the Eastern Desert of Egypt*, pp. 221, 265.

⁴ A. Lucas, *Ancient Egyptian Materials*, first edition, 1926, p. 181.

⁵ O. H. Little, *Prelim. Report on some Geol. Specimens from the 'Chephren Diorite' Quarries, Western Desert*, in *Annales du Service*, xxxiii (1933), pp. 75-80.

Simbel in Nubia.^{1, 2} This white-banded and white flecked with black rock is only a special variety, possibly, however, unique, of a diorite that occurs in other localities, one of which is Aswan.³ Another variety of diorite (porphyritic-diorite), composed of a compact black matrix in which are embedded conspicuous white fragments, will be considered when dealing with porphyry.

Dolerite

As already explained,⁴ dolerite is merely a coarse-grained basalt and there is no fundamental difference and no hard and fast line of demarcation between the two.

Dolerite occurs in several localities in the eastern desert of Egypt, namely, in the neighbourhood of Wâdi Esh near Quseir ⁵; in Wâdi Atolla, a little south of Wâdi Esh, where in one place the rock is marked with a cartouche of Ramesses III (Twentieth Dynasty) ⁶ and near Gebel Dokhan, where there are ancient quarries probably of Roman date ⁷; it is also found in Sinai.

One important use of dolerite in ancient Egypt was for pounders for working hard stone, and roughly spherical specimens of this rock may still be seen in large numbers in the ancient granite quarries at Aswan and in the quartzite quarry at Gebel Ahmar near Cairo, where they have remained since they were employed by the ancient quarrymen. Spherical masses of dolerite, resembling these pounders, occur naturally in certain places in the cataract regions of the Nile and in the eastern desert.⁸

Dolomite

Dolomite is a definite compound (and not merely a mixture) of calcium carbonate and magnesium carbonate in the proportion of 54.4 per cent of the former and 45.6 per cent of the latter. Magnesium carbonate is a very common constituent of limestone, but is usually present in very small proportions,

¹ R. Engelbach, *The Quarries of the Western Nubian Desert*, in *Annales du Service*, xxxiii (1933), pp. 65-74.

² W. F. Hume, *Geology of Egypt*, II (Part I), pp. 299-300.

³ Professor G. Andrew, lecture at l'Institut d'Égypte, January 8th, 1934.

⁴ See p. 59.

⁵ T. Barron and W. F. Hume, *op. cit.*, pp. 52, 263.

⁶ *Id.*, pp. 217, 263.

⁷ *Id.*, pp. 26, 236.

⁸ W. F. Hume, *Preliminary Report on the Geology of the Eastern Desert*, p. 49.

thus out of 132 specimens of limestone from the neighbourhood of Cairo analysed by the author all contained magnesium carbonate, but only 15 contained more than 5 per cent and only two contained more than 20 per cent, the proportion of magnesium carbonate in these being 30 per cent and 37 per cent respectively. When the proportion of magnesium carbonate is substantial, as in the two cases mentioned, but not sufficient to form dolomite, the rock is termed dolomitic limestone (or magnesian limestone) and, since dolomite and dolomitic limestone are so much alike that they cannot be distinguished except by chemical analysis, they are usually classed together.

Both dolomite and dolomitic limestone were employed in ancient Egypt in early dynastic times for bowls and vases and probably occasionally at later periods for other objects. Petrie reports 44 vases of what is termed 'dolomite marble' from the First Dynasty^{1, 2} and the author has analysed the material of a number of broken vases of Third Dynasty date from Saqqâra, some of which were dolomite or practically dolomite and others dolomitic limestone.

Petrie, describing the 'dolomite marble,' says³: 'This material varies much, but cannot be confounded with any other class. It is hard, opaque, white with veins; sometimes the veining is of clearer white, but usually of grey and sometimes of quartz, almost black. The magnesia of the dolomite is left on the surface as a powdery white incrustation, if it has been exposed to solution by weathering.'

The specimens examined by the author have all been white with veins or patches of dark grey; the surface has always been dull, though probably it was polished originally; the white has been chalky in appearance and a fine white powder has rubbed off when the specimens have been handled. The characteristic appearance of this stone, together with the fact that cold dilute hydrochloric acid causes little or no effervescence, makes it easy to identify. Dolomite occurs in the eastern desert in several localities.⁴

¹ W. M. Flinders Petrie, *The Royal Tombs of the Earliest Dynasties*, II, p. 41, Pls. IX (2-10); II (c, d, e).

² W. M. Flinders Petrie, *Abydos I*, p. 7; Pl. IX (5, 6, 7, 10).

³ W. M. Flinders Petrie, *The Royal Tombs*, p. 44.

⁴ W. F. Hume, *Geology of Egypt*, II (Part 1), pp. 89, 144, 160.

Flint, Chert

The stone first used in Egypt, as in many other countries, was flint, and from it, before metal was known, Stone Age man fashioned his weapons and tools and even long after copper was generally employed, the use of flint, although it naturally decreased considerably, did not entirely cease, but continued for certain purposes, some of which were purely ceremonial.

Flint was also used at an early date for personal ornaments, chiefly bracelets, and occasionally even for bowls, one such having been found in the Fourth Dynasty temple of Mycerinus.¹

Flint consists of a very compact form of silica; it is dark grey or black in colour; breaks with a conchoidal fracture and affords sharp cutting edges; it occurs plentifully in certain districts in Egypt in the form of nodules and layers in the limestone rock and in such localities it is also found scattered about the surface of the desert, having been freed by the weathering of the limestone.

Chert is an impure kind of flint of a light grey or light brown colour and, although it is largely composed of silica, it breaks with a more or less flat fracture instead of the conchoidal fracture of flint; it occurs like flint in limestone and was sometimes used in place of flint.

Granite

Granite has already been described in connexion with building materials,² where it was stated to be the name of a large class of crystalline rocks of igneous origin, the individual minerals of which, chiefly quartz, felspar and mica, are sufficiently large to be visible to the naked eye. The typical granite of ancient Egypt is the coarse-grained red variety that forms the greater part of the hills between Aswan and Shellâl. This is a true granite and its recognition presents no difficulty and leaves no room for doubt or confusion. Granite, however, being a natural material is not uniform in structure, composition or even colour, but varies considerably in all three respects, thus the grain of the rock may be coarse or fine, the relative proportion or distribution of the contained minerals may vary and the felspar

¹ G. A. Reisner, *Mycerinus*, p. 102.

² See p. 54.

may be red, white or occasionally green, the rock in the first case being coloured red, in the second case, black and white or light grey, or when the darker minerals (mica and hornblende) preponderate, dark grey or even practically black and in the third case green. Granite, too, merges into rocks of other types without any hard and fast line of demarcation.

The geologist divides granite into a number of sub-classes in accordance with their composition, but with these divisions Egyptology is not concerned, all that is required being a broad classification, subtle distinctions being quite unnecessary. There will probably be some difference of opinion as to the degree of elasticity that may be allowed in calling stone granite, or in other stone nomenclature, but for the purposes of Egyptology the boundaries should be as wide as possible.

Granite was employed in predynastic times, though only sparingly and chiefly for bowls and vases,¹ but in the early dynastic period it was worked to a much greater extent on account of the increased use of copper tools and, in addition to its use as a building material, it was also employed for sarcophagi, and at later periods for statues, obelisks, stelæ and other objects.

The occurrence of granite in Egypt has already been described ² in connexion with its use for building purposes.

Gypsum, Anhydrite

Gypsum, as already explained when dealing with plaster,³ although often occurring in scattered masses of loosely aggregated crystals, quite useless for carving, is also found in compact rock-like formation, for example in the Mariout region to the west of Alexandria ; between Ismailia and Suez ; in the Fayûm and very plentifully near the Red Sea coast.

Gypsum consists of hydrated calcium sulphate and in appearance it much resembles alabaster (calcite), which is calcium carbonate, and it is often called alabaster and even claims, probably wrongly, priority for the name.

Apart from its use for mortar and plaster, gypsum was

¹ For references, see A. Lucas, *Egyptian Predynastic Stone Vessels*, in *Journal of Egyptian Archaeology*, XVI (1930), p. 201.

² See p. 56.

³ See p. 77.

employed only to a comparatively small extent in ancient Egypt. Miss Caton-Thompson has shown that a very large number of gypsum vases and dishes were made in the Fayûm during the Third Dynasty¹ and Petrie found at Giza² several intact and many broken gypsum vases of Second or Third Dynasty date that probably came from the Fayûm factory. Among the objects from the tomb of Tut-ankhamûn two of the knobs on the saddles of the chariot harness are gypsum, the others that have been tested being alabaster (calcite).³ Petrie found a gypsum dish⁴ of predynastic date and a few gypsum boxes of Roman date.⁵

Until recently a pale blue material used chiefly in the Middle Kingdom for small vases was assumed to be marble on account of its appearance and has always been called 'blue marble,' but a doubt about the identity of the material having been raised Mr. O. H. Little, Director of the Geological Survey of Egypt, determined the specific gravity of a fragment and found that it was not marble, but anhydrous calcium sulphate (anhydrite), and the author made a chemical analysis with the same result. The source of this material is not known, but it is most probably local.

Gypsum is softer than alabaster (calcite) and may be scratched with the finger-nail, whereas alabaster cannot be scratched with anything softer than steel. The anhydrous form of calcium sulphate (anhydrite) is about the same hardness as calcite.

Limestone

Limestone has already been dealt with in connexion with building materials.⁶ In addition to this use, however, it was largely employed for other purposes and it was one of the first stones used, except for weapons and tools, because it was soft and easily worked and also because it lent itself admirably to

¹ G. Caton-Thompson, *Recent Excavations in the Fayûm*, in *Man*, XXVIII (1928), 80.

² W. M. Flinders Petrie, *Gizeh and Rifeh*, p. 7.

³ A. Lucas, *Appendix II*, p. 168, in *The Tomb of Tut-ankh-Amen*, II, Howard Carter.

⁴ W. M. Flinders Petrie, *Prehistoric Egypt*, p. 36.

⁵ W. M. Flinders Petrie, *Hyksos and Israelite Cities*, p. 58; Pl. XLIII (24-31).

⁶ See p. 47.

carving on account of its fine texture ; its use dates back to neolithic times. The wide distribution of limestone in Egypt has already been mentioned.

Marble

Marble is a crystalline form of limestone having a compact structure that enables it to take a high polish ; it is usually white or grey, but may be of almost any colour and is often veined in different colours.

The known occurrences of marble in Egypt are chiefly confined to the eastern desert, where it is recorded from several localities,^{1, 2, 3} namely, a grey saccharine-looking variety from Wâdi Dîb (west of Gebel Zeit and fairly close to the Red Sea coast) and both a white and a colourless kind from Gebel Rokham (near the upper part of Wâdi Miah, east of Esna and roughly two-thirds of the way between the Nile and the Red Sea), the latter of which was exploited to a small extent in Arab times⁴ and possibly earlier ; a third occurrence is in the far south-eastern desert⁵ ; a hard crystalline limestone, practically marble occurs at El-Amârna and recently a yellowish-grey, very nummulitic marble with brown patches has been discovered at Geran el-Fûl on the northern edge of the plateau to the west of the Giza pyramids. This, however, was not used and was probably not known anciently. From where the comparatively small amount of marble employed anciently was obtained is not known.

Marble was used to a small extent for vases in predynastic and early dynastic times⁶ ; it was used for statues during the Eighteenth and Nineteenth Dynasties (examples : a beautiful small statue of Tuthmosis III in white marble slightly veined in grey, now in the Cairo Museum,⁷ and a number of large

¹ W. F. Hume, *Explan. Notes to the Geol. Map of Egypt*, p. 47.

² T. Barron and W. F. Hume, *The Topog. and Geol. of the Eastern Desert of Egypt*, pp. 32, 119, 240, 266-7.

³ W. F. Hume, *Geology of Egypt*, II (Part I), pp. 101, 171, 172.

⁴ J. Barthoux, *Mém. de l'Inst. d'Égypte*, V (1922), p. 33.

⁵ J. Ball, *The Geog. and Geol. of South-Eastern Egypt*, pp. 348-9.

⁶ For references, see A. Lucas, *Egyptian Predynastic Stone Vessels*, in *Journal of Egyptian Archaeology*, XVI (1930), p. 201.

⁷ No. J. 43507 A.

statues in the temples at Luxor and Karnak respectively and several in the Cairo Museum) and it was employed for statues and portrait heads in Roman times, numerous examples of which are in the Museums at Cairo and Alexandria. Fragments of what are possibly foreign marble from Greece have been found in excavations at Alexandria.

Pliny mentions¹ 'marbles of Alexandria,' the Augustan and Tiberian, which were discovered in Egypt in the reigns of the emperors Augustus and Tiberius respectively. The stones, he explains, differ 'in the arrangement of their spots,' one having them 'undulated and curling to a point,' whereas in the other 'the streaks are white, not involved, but lying wide asunder.'

This same writer also mentions¹ a third kind of marble called '*memphites*' after Memphis, where it was found, which he says was 'of a nature somewhat analogous to the precious stones.' Whether all, or any, of these stones were marble in the modern sense is uncertain, though if *memphites* were indeed obtained from near Memphis, it was probably some sort of limestone, since no other kind of stone is known to occur in that locality.

The so-called 'blue marble,' used principally in the Middle Kingdom for making small vases, as already stated,² is not marble but anhydrite.

Obsidian

Obsidian is a glassy-looking material that breaks with the conchoidal fracture of glass and is a natural glass of volcanic origin; the colour is usually black, but may be dark brown, dark grey or dark green; in thin sections it is translucent.

So far as is known obsidian is not found naturally in Egypt, but it occurs in Abyssinia,³ in the *wâdis* (valleys) in the peninsula of Aden⁴ and elsewhere in Arabia,⁵ in Armenia, in various Mediterranean islands and in other places.

Obsidian was used in ancient Egypt in small amount from predynastic times,⁶ at first in the form of flakes for use as

¹ xxxvi, 11.

² See p. 365.

³ H. Salt, *A Voyage into Abyssinia*, pp. 190-4.

⁴ From private information. ⁵ R. F. Burton, *The Land of Midian*, 1, p. 282.

⁶ W. M. Flinders Petrie, *Prehistoric Egypt*, p. 43.

implements and as weapons, such as lance-heads,¹ and later as amulets, beads, scarabs, small vases, eyes and pupils of eyes in statues and other purposes, notable examples of its use being the head of Amenemhet III (Twelfth Dynasty)² and a broken mask³ and small head³ of Eighteenth Dynasty date in the Cairo Museum.

The subject of the use of obsidian in ancient Egypt, with particular reference to the origin of the material, has been discussed at length by Wainwright⁴ and shortly by Frankfort,⁵ the latter of whom gives some physical constants of obsidian from various sources. Wainwright's conclusion, after an exhaustive examination of all the evidence, is that the obsidian used in Egypt was obtained from Armenia. The author would venture to suggest, however, that as there was a coasting trade down the Red Sea from very early times, and as obsidian occurred on the coast of Abyssinia⁶ and in Arabia, some of that employed in Egypt may have been obtained from one or other of these countries, for instance the flakes found in Nubia⁷ and the lumps from Napata.⁸ Pliny apparently knew of Abyssinia as a source of obsidian⁹ as also did the author of the *Periplus of the Erythraean Sea*,¹⁰ which seems to indicate that in the first century A.D. at least, if not before, obsidian had been obtained from Abyssinia.

Porphyritic Rock

The name porphyry (derived from a word meaning purple) was originally applied to a certain kind of purple-tinted rock (imperial porphyry), but in geology this primary significance has given place to one in which structure, and not colour, is the guiding characteristic, a porphyritic rock being any kind of

¹ There is a fine forked lance-head of predynastic date in the Cairo Museum (No. J. 56605).

² C. Ricketts, *Journal of Egyptian Archaeology*, IV (1917), pp. 71-3.

³ G. Legrain, *Statues et Statuettes, Cat. Gén. du Musée du Caire*, I, pp. 58-9.

⁴ G. A. Wainwright, *Obsidian*, in *Ancient Egypt*, 1927, pp. 77-93.

⁵ H. Frankfort, *Studies in Early Pottery of the Near East*, II, pp. 190-3.

⁶ The coast now no longer belongs to Abyssinia.

⁷ G. A. Wainwright, *op. cit.*, p. 88.

⁸ G. A. Wainwright, *op. cit.*, p. 91.

⁹ xxxvi, 67.

¹⁰ W. H. Schoff, *The Periplus of the Erythraean Sea*, pp. 23, 66.

igneous rock in which there are conspicuous crystals scattered throughout a differently coloured ground-mass or matrix of apparently homogeneous material.

Porphyritic rocks varying considerably both in the nature and size of the conspicuous crystals and also in colour are widely distributed in Egypt¹ and occur near Aswan, in the eastern desert and in Sinai.

Porphyritic rock was used in the predynastic and early dynastic periods for making vessels, the particular variety generally chosen being black and white (white crystals in a black matrix). There is no evidence to show from where this stone was obtained, and although the porphyritic rocks in the Geological Museum have been carefully examined no specimen identical with the stones employed anciently could be found. Dr. Hume, however, informs the author that similar rocks do occur in the eastern desert.

The best known of the porphyritic rocks quarried anciently is without doubt the beautiful fine-grained purple-coloured rock, often termed imperial porphyry, that was obtained from Egypt by the Romans and employed extensively in Italy as an ornamental stone. This is found in three localities in the eastern desert, namely at Gebel Dokhan,^{2, 3} which is situated in about the same latitude as Asyût, but nearer the Red Sea than the Nile; at Gebel Esh,² some distance north-east of Dokhan and nearer the coast and at El Urf near Wâdi Dîb.² It was from the first-named locality, however, that the Romans obtained their supply.

Probably the Egyptian stone referred to by Pliny,⁴ which he describes as being of a red colour and which he calls *porphyrites*, was imperial porphyry. The quarries, Pliny says, were able to furnish blocks of any dimensions however large. He also states that certain columns in the Egyptian Labyrinth were of *porphyrites*⁵; he further says that the steward in Egypt for the

¹ For references, see A. Lucas, *Journal of Egyptian Archaeology*, xvi (1930), p. 202.

² T. Barron and W. F. Hume, *Topog. and Geol. of the Eastern Desert of Egypt* pp. 118, 238, 241, 262.

³ W. F. Hume, *Geology of Egypt*, II (Part I), pp. 273-82.

⁴ xxxvi, 11.

⁵ xxxvi, 19.

emperor Claudius brought to Rome from Egypt statues made of this stone, 'a novelty which was not very highly approved of, as no one has since followed his example.'¹

Only one example of the use of imperial porphyry in Egypt before Roman times is known to the author, this being part of a small fluted bowl, probably of Old Kingdom date, found at Ballâs in Upper Egypt.² This, however, does not mean that imperial porphyry was being quarried at such an early period, as a piece sufficiently large to make the bowl in question might well have been found lying loose on the surface of the desert in the neighbourhood of where the porphyry occurs.

Even at a late period date, imperial porphyry seems rarely to have been employed in Egypt, as only very few objects made from it can be traced, namely, a bust of a Roman emperor in the Cairo Museum; a carved lid of a sarcophagus of late date in the Alexandria Museum³; a large mutilated statue of a male figure seated on a throne, possibly dating from the fourth century A.D., also in the Alexandria Museum⁴; a torso of a Byzantine emperor from Alexandria in the Emperor Frederick Museum at Berlin and some re-used pieces of Roman date built into the *Madrassa* of the Sultan Barqûq mosque at Cairo.⁵

Quartzite

Quartzite and its occurrence in Egypt have already been dealt with in connexion with building materials,⁶ but in addition to its use for building this stone was employed extensively for other purposes, principally for sarcophagi and statues, examples of the former being the sarcophagus in the Hawara pyramid (Twelfth Dynasty) and the sarcophagi of Tuthmosis I, Hatshepsût and Tut-ankhamûn respectively (all Eighteenth Dynasty) and examples of the latter being a head of Dedefrê (Fourth Dynasty) and the statues of Sesostri III (Twelfth Dynasty), Tuthmosis IV, and Senmut (both Eighteenth Dynasty), Ptah (Nineteenth Dynasty) and the emperor Caracalla (Roman).

With respect to the nature of the stone of which the Colossi

¹ xxxvi, 11.

² W. M. Flinders Petrie and J. E. Quibell, *Naqada and Ballas*, pp. 10, 36.

³ Ev. Breccia, *Alexandria ad Aegyptum*, 1922, p. 103.

⁴ *Id.*, p. 235.

⁵ Kindly communicated by Captain A. Creswell.

⁶ See p. 60.

of Memnon are made, there is a considerable difference of opinion,¹ and until the bases of these statues have been cleaned from the accumulated mud of many inundations that covers them and unless a ladder is available to reach the upper part, it is impossible to examine them properly. It may be mentioned, however, that the 'pebbly' nature of part of the stone, which seems to be a difficulty with some archæologists in assigning the stone to Gebel Ahmar, may be closely matched in the very coarse material from that quarry.

Sandstone

Sandstone has already been dealt with as a building material,² but it was also employed for many other purposes, such as statues, stelæ and other objects. Notable examples of its use are the statues of Akhenaten (Eighteenth Dynasty) from Karnak, discovered a few years ago, and the colossal statues at Abu Simbel (Nineteenth Dynasty).

Schist, Tuff, Mudstone, Slate

Schist is the term applied to certain rocks having a fissile or foliated structure, which however is not always very evident, and the name has no relation to the composition of the rock, which may be very varied. The particular schist employed by the ancient Egyptians was a fine-grained, compact, hard, crystalline, quartzose, metamorphic rock, very like slate in appearance and generally of various shades of grey, ranging from light to dark, with often a greenish tint. With this schist may be grouped other allied rocks, namely, tuff (volcanic ash), mudstone and slate, since they are frequently so much alike that they cannot be distinguished except by a microscopical examination of thin sections, and they all occur in the same locality.

The tuff is a fine-grained, bluish-grey, crystalline rock, very like schist or slate in general appearance, which consists of consolidated volcanic ash, sometimes calcified, that is to say it has sometimes undergone alteration resulting in the formation of a small amount of calcium carbonate as one of the products

¹ A. Varille, *L'inscription dorsale du colosse méridional de Memnon*, in *Annales du Service*, xxxiii (1933), pp. 85-94.

² See p. 51.

of the change. The mudstone is a compact rock, very similar to tuff and is probably the material for which Petrie coined the term 'durite,' which he describes as 'a metamorphic volcanic mud, much like slate in composition, but not in fracture.'¹ Slate is generally a hard, fissile clay-schist, though not invariably, since slate formed from volcanic dust is known.

Schist, tuff and mudstone were employed during the pre-dynastic² and early dynastic periods for bowls, vases and palettes and later for sarcophagi, naos and statues, slate being sometimes used during the earlier periods for palettes.

Schist,^{3, 4, 5, 6} tuff^{7, 8} and slate^{9, 10} all occur in several localities in the eastern desert, though the principal and possibly the only ancient source of the two former (schist and tuff) was the neighbourhood of the Wâdi Hammamât on the main road from Qena to Quseir, where there are extensive ancient quarries with more than 250 inscriptions ranging in date from the First Dynasty to the Thirtieth Dynasty.¹¹⁻¹⁴ These quarries and the stone from them are frequently mentioned in the ancient records.¹⁵

Until quite recently it was generally believed that the grey

¹ W. M. Flinders Petrie, *Amulets*, p. 8.

² For references, see A. Lucas, *Journal of Egyptian Archaeology*, xvi (1930), p. 201.

³ See Geological Map.

⁴ T. Barron and W. F. Hume, *op. cit.*, pp. 217-21, 224, 226, 236, 238-9, 249, 264.

⁵ J. Ball, *The Geog. and Geol. of South-Eastern Egypt*, pp. 337-50.

⁶ W. F. Hume, *Geology of Egypt*, II (Part I), pp. 263-6.

⁷ T. Barron and W. F. Hume, *op. cit.*, pp. 221, 236, 239, 249.

⁸ W. F. Hume, *op. cit.*, pp. 249-50.

⁹ T. Barron and W. F. Hume, *op. cit.*, pp. 217-18, 221, 226, 238, 264.

¹⁰ W. F. Hume, *op. cit.*, pp. 194, 203, 227-8, 230, 256.

¹¹ A. E. P. Weigall, *Travels in the Upper Egyptian Deserts*, p. 39.

¹² J. Couyat et P. Montet, *Les inscriptions hiéroglyphiques et hiératiques du Ouadi Hammamât*, in *Mém. de l'Inst. franc. d'archéol. orientale du Caire*, xxxiv (1912), pp. 122-3.

¹³ J. H. Breasted, *op. cit.*, I, 7, 10, 295-301, 386-9, 427-56, 466-8, 674-5, 707-9; IV, 457-68.

¹⁴ W. M. Flinders Petrie, *A History of Egypt*, I (1923), pp. 102, 110, 144, 146, 153, 161, 175, 184, 193, 233; II (1924), pp. 97, 206; III (1928), pp. 119, 166, 280-1, 288, 294, 335, 340, 348, 360, 364, 369-70.

¹⁵ J. H. Breasted, *op. cit.*, v (Index), p. 79.

schist of the Wâdi Hammamât was the ancient *bekhen* stone, and this was thought to be proved by the fact that a certain naos of Nectanebo II, which is stated on the object itself to be of *bekhen* stone,¹ is certainly the Wâdi Hammamât schist. (Two miniature obelisks of Horemhab of this schist are not called *bekhen* stone.^{2, 3}) It has now been shown, however, by Varille⁴ that at least one other (and possibly more) totally different kind of stone was also termed *bekhen* stone, for example, the naos of Amasis II, which is not schist, but a fine-grained grey granite.⁵

In the British Museum there are two small obelisks of Nectanebo II that bear inscriptions describing the stone of which they are made as *bekhen*. In the Museum Guide this stone is called 'black basalt'⁶ and Breasted, on the authority of Gardiner, states that they are 'of the black basaltic rock of Hammamât'⁷ though, so far as the author can ascertain, there is no basalt, black or otherwise, in the neighbourhood of the Wâdi Hammamât. These obelisks have been much repaired, and afterwards apparently covered with a wash of black colour and it is impossible for the ordinary visitor to the Museum to ascertain the nature of the stone. Kuentz, however, has recently proved that a fragment in the Cairo Museum belongs to one of these obelisks,⁸ and this fragment has been examined by Bovier-Lapierre and pronounced to be 'gneiss à structure micro-

¹ G. Roeder, *Naos*, in *Cat. Gén. du Musée du Caire*, pp. 55-6 (No. 70019). Roeder calls the stone 'gruner Schiefer.' Earlier writers have variously termed it green breccia, green basalt and black granite, but it is undoubtedly the Wâdi Hammamât schist.

² C. Kuentz, *Obélisques*, in *Cat. Gén. du Musée du Caire*, pp. 32-4 (Nos. 17017 and 17018). The stone is undoubtedly the typical light-grey Wâdi Hammamât schist.

³ W. F. Hume, *Geology of Egypt*, II (Part I), pp. 265, 300.

⁴ A. Varille, *Quelques données nouvelles sur la pierre bekhen des anciens Égyptiens*, in *Bull. de l'Inst. franc. d'archéol. orientale*, xxxiv (1933), pp. 93-102.

⁵ G. Roeder, *op. cit.*, pp. 38-42 (No. 700011). This stone, which is in the Cairo Museum, is certainly 'grau gesprenketer feinkorniger Granit' as stated by Roeder.

⁶ British Museum, *A General Introductory Guide to the Egyptian Collections*, 1930, p. 395.

⁷ J. H. Breasted, *op. cit.*, I, p. 302, note a.

⁸ C. Kuentz, *op. cit.*, pp. 61-2.

granitique avec amphibole.'¹ Unfortunately any thoroughly satisfactory examination of the stone is impossible for the moment, since there is no clean, unworn fracture and since microscopic examination of a thin section is precluded, but the author hopes to be able to make a complete examination at some future date. From the partial examination that alone is now possible the stone appears to be schist, though darker than the typical Wâdi Hammamât schist.

Serpentine, Steatite

Serpentine and steatite are very similar in composition, though not identical, both being hydrated silicates of magnesium, but in different states of hydration.

Serpentine is a non-crystalline rock of a dull serpent-like mottled appearance, usually dark green to almost black in colour; it is fairly soft, though harder than steatite, and may readily be cut or scratched; it is widely distributed in the eastern desert, the principal centres being the Baramia-Dungash area,² in Wâdi Shait,² near Gebel Derrera,² in the hills north of Sikait² and at Gebel Sikait,² in the Muqsim area² and in the far eastern desert where it covers an area of about 400 square miles from Ras Benas southwards to Cape Elba.^{3, 4} A green variety occurs in Wâdi Umm Disi⁵ (which is situated between Wâdi Qena and the Red Sea) and at the foot of Gebel El-Rebshi,⁵ and a black variety in Wâdi Sodmên,⁵ both these latter places being north-west of Quseir. Serpentine was employed for vases⁶ and other objects⁷ as early as predynastic times. A head of Amenemhet III (Twelfth Dynasty) is of this material.⁸

Steatite is a form of talc and is usually white or grey in colour, though occasionally it is smoke-black, this latter colour being

¹ A. Varille, *op. cit.*, p. 96

² W. F. Hume, *A Prelim. Report on the Geol. of the Eastern Desert*, p. 34.

³ J. Ball, *The Geog. and Geol. of South-Eastern Egypt*, pp. 320-30.

⁴ W. F. Hume, *Geology of Egypt*, II (Part I), pp. 144-59.

⁵ T. Barron and W. F. Hume, *op. cit.*, p. 265.

⁶ For references, see A. Lucas, *Journal of Egyptian Archaeology*, XVI (1930), p. 201.

⁷ W. M. Flinders Petrie, *Prehistoric Egypt*, p. 44.

⁸ C. Ricketts, *Journal of Egyptian Archaeology*, IV (1917), pp. 211-12.

natural and not artificial, as has been stated ; it has a greasy or soapy feel and was used from predynastic times onwards for beads and other small objects,¹ which were sometimes glazed, the greater proportion of the scarabs known being of glazed steatite.

Steatite is found at Hamr near Aswan,² at Gebel Fatira³ (about the latitude of Tahta, but much nearer the coast than the Nile) and in Wâdi Gulan (opposite Gulan Island, which is north of Ras Benas), where it is now being exploited.⁴ In the former locality there are ancient mines, which were temporarily reopened in 1918 when 137 tons of material were extracted³ ; it has been worked on a very small scale for many years by the local 'Arabs,' who fashion it into bowls and pipes.

¹ W. M. Flinders Petrie, *Prehistoric Egypt*, p. 44.

² W. F. Hume, *Geology of Egypt*, II (Part I), pp. 131-2, 164-5.

³ Mines and Quarries Department, *op. cit.*, p. 37.

⁴ Information kindly supplied by Mr. O. H. Little, Director, Geological Survey of Egypt.

CHAPTER XIV

WOOD

Egypt is, and during the historical period always has been, poorly provided naturally with large trees and it has been necessary from very early times to import a portion of the wood required (though probably not so much as is sometimes thought), a practice that continues to the present day, and on the Palermo Stone it is stated¹ that as early as the reign of Snefru (Third Dynasty) 40 ships laden with timber were brought to Egypt.

FOREIGN TIMBER

The places from which the foreign timber (excluding ebony) was obtained were Arrapachitis,² Assur,³ God's Land,⁴ the Hittite country,⁵ Lebanon,⁶ Naharin,⁷ Punt,⁸ Retenu⁹ and Zahi,¹⁰ all except Punt (the wood from which consisted of ebony and certain sweet and fragrant woods, the latter manifestly not being for use as timber but probably for making incense and perfumes) being situated in western Asia.

Although a large number of different kinds of wood are mentioned by name in the ancient records, only comparatively few of these names have been translated¹¹ and, even where this has been done, the translation is often only a tentative one

¹ J. H. Breasted, *Ancient Records of Egypt*, I, 146. ² II, 509, 512.

³ II, 449. ⁴ II, 321, 888. ⁵ II, 485. ⁶ III, 94; IV, 577.

⁷ III, 434. ⁸ II, 265; III, 527. ⁹ II, 447, 471, 491, 509, 525, 838.

¹⁰ II, 490.

¹¹ In Breasted's translation of the ancient Egyptian records, in addition to such indefinite names as aromatic wood, fire wood, fragrant wood and sweet wood, the names of 12 woods, out of a total of 24, are left untranslated.

and is not always generally accepted and the identity of much of the imported timber still remains doubtful.

The only certain method of identifying wood is by an expert examination of its structure with a microscope, and the following list gives all such identifications of foreign woods (except ebony) found in Egypt that can be traced :

Wood	Date	Object
Beech . . .	3rd to 4th century A.D. . .	Mummy label ¹
Box . . .	3rd to 4th century A.D. . .	Mummy labels ¹
Cedar . . .	Predynastic period . . .	Small pieces ²
Cedar . . .	Xth to XIth Dynasty . . .	Coffins ¹
Cedar . . .	XIIth Dynasty . . .	Sarcophagus ^{3, 4}
Cedar . . .	Middle Kingdom . . .	Coffin ⁵
Cedar . . .	XVIIIth Dynasty . . .	Shrines (panels) ⁶
Cedar . . .	XVIIIth Dynasty . . .	Shrines (tongues) ⁶
Cedar . . .	XXth to XXVIth Dynasty . . .	Coffin ⁵
Cedar . . .	XXVIth Dynasty . . .	Coffin ³
Cedar . . .	Ptolemaic . . .	Coffin or coffins (two pieces) ⁷
Cedar . . .	About 2nd century A.D. . .	Tree trunk (small) ⁸
Cypress . . .	Predynastic period . . .	Small pieces ²
Cypress . . .	IIIrd Dynasty . . .	Coffin ⁹
Cypress . . .	End of Saïte period . . .	Coffin ³
Fir . . .	Vth Dynasty . . .	Vase (part of) ¹⁰
Fir . . .	Late 7th century B.C. . .	Coffin ³
Fir . . .	Roman . . .	Mummy label ⁷

¹ K. P. Oakley, *Woods used by the Ancient Egyptians*, in *Analyst*, LVII (1932), pp. 158-9.

² G. Brunton and G. Caton-Thompson, *The Badarian Civilisation*, pp. 62-3.

³ R. Engelbach, *Ancient Egyptian Woods*, in *Annales du Service*, xxxi (1931), p. 144.

⁴ The coffin and canopic box belonging to this burial are also cedar.

⁵ Kindly identified for the author by Dr. L. Chalk (The Imperial Forestry Institute, University of Oxford, *Eighth Annual Report*, 1931-2, p. 11).

⁶ Several specimens kindly identified for the author by Dr. L. Chalk (The Imperial Forestry Institute, Oxford, *op. cit.*, p. 11); a number of other specimens identified by the author.

⁷ W. Ribstein, *Zur Kenntnis der im alten Ägypten verwendeten Hölzer*, in *Botanisches Archiv.*, pp. 194-209. Herausgegeben von Dr. Carl Mez, Königsberg. Neither volume nor date given.

⁸ G. W. Murray, *A Small Temple in the Western Desert*, in *Journal of Egyptian Archaeology*, xvii (1931), p. 82.

⁹ Kindly identified for the author by Dr. L. Chalk (The Imperial Forestry Institute, University of Oxford, *Ninth Annual Report*, 1932-3, p. 12).

¹⁰ L. Borchardt, *Das Grabdenkmal des Königs Nefer-ir-ke-Re*, pp. 61, 63.

Wood	Date	Object
Juniper . . .	IIIrd Dynasty . . .	Coffin ¹
Juniper . . .	About IIIrd Dynasty . . .	Lid (small) ²
Juniper . . .	Roman . . .	Mummy label ²
Lime . . .	3rd to 4th century A.D. . .	Mummy label ³
Oak . . .	XVIIIth Dynasty . . .	Shrines ⁴
Pine . . .	Predynastic period . . .	Piece (trimmed) ⁵
Pine . . .	IIIrd Dynasty . . .	Coffin ¹
Yew . . .	VIth to XIIth Dynasty . . .	Coffins ⁶
Yew . . .	VIth to XIIth Dynasty . . .	Coffin peg ⁶
Yew . . .	XVIIIth Dynasty . . .	Head of Queen Tyi ^{7, 8}

The various woods enumerated may now be considered.

Beech

The beech tree (*Fagus sylvatica*) is found both in Europe and in western Asia and the occurrence, therefore, of a small specimen of the wood in Egypt at a late date is not surprising.

Box

The box tree (*Buxus sempervirens*) grows in Europe, western Asia and north Africa and, since the wood was used by both the Greeks ⁹ and Romans,¹⁰ it is in no way strange that a small piece should have been found in Egypt at a late period.

Cedar

There is only one family of true cedars, which comprises three members, namely, the cedar of Lebanon (*Cedrus Libani*); the Atlas cedar (*Cedrus atlantica*) and the Indian cedar (*Cedrus*

¹ Kindly identified for the author by Dr. L. Chalk (The Imperial Forestry Institute, University of Oxford, *Ninth Annual Report*, 1932-3, p. 12).

² W. Ribstein, *Zur Kenntnis der im alten Ägypten verwendeten Hölzer*, in *Botanisches Archiv.*, pp. 194-209. Herausgegeben von Dr. Carl Mez, Königsberg. Neither volume nor date given.

³ K. P. Oakley, *Woods used by the Ancient Egyptians*, in *Analyst*, LVII (1932), pp. 158-9.

⁴ Howard Carter, *The Tomb of Tut-ankh-Amen*, II, p. 39; III, p. 153.

⁵ G. Brunton and G. Caton-Thompson, *op. cit.*, pp. 62-3.

⁶ G. Beauvisage, *Recherches sur quelques bois Pharaoniques*, in *Recueil de travaux*, xviii (1896), pp. 78-90.

⁷ L. Borchardt, *Der Porträtkopf der Königen Teje*, p. 10.

⁸ L. Wittmack, *Holz vom Porträtkopf der altägyptischen Königen Teje*, in *Berichten der Deutschen Botanischen Gesellschaft*, xxx (1912), pp. 275-8.

⁹ Theophrastus, *Enquiry into Plants*, v, 3, 7; v, 7, 7-8.

¹⁰ Pliny, xvi, 28.

deodara). Although it is not impossible that the wood of the Atlas cedar (which grows on the Atlas mountains in Morocco) might occasionally have found its way into Egypt, there is no evidence and little probability of this, the ancient imports of timber into Egypt (excepting ebony) being chiefly from Syria; and, although the woods of the Lebanon and Atlas cedars cannot be distinguished from one another microscopically, it may be accepted that any cedar wood found in Egypt is *Cedrus Libani* and, since its use goes back to the predynastic period, it was evidently being imported into Egypt at that early date.

At the present day a large number of different trees that are not cedar are called cedars,¹ among them being one (an American juniper, *Juniperus virginiana*) that yields the fragrant red wood employed for making pencils, cigar boxes and other objects. The modern 'oil of cedar,' too, is generally a product of this same tree. This confusion of nomenclature, however, is not new, as the classical writers, both Greek and Latin, applied the term 'cedar' to many trees that were not cedars, but often junipers.² It seems, therefore, not only possible, but probable, that the word 'cedar' has always been used in a loose manner and that, even when there is no longer any difference of opinion about the ancient Egyptian name for the true cedar, there will still remain a doubt whether a particular wood so designated was indeed cedar, though in view of the results given, there cannot be any uncertainty about the fact that the wood of the true cedar was employed in Egypt for making sarcophagi, coffins and other appurtenances of burial, such as shrines, from at least as early as the Tenth or Eleventh Dynasty to as late as the Ptolemaic period.

The Eighteenth Dynasty shrines of which specimens of the wood have been examined are those that enclosed the stone sarcophagus (containing the nest of three coffins with the mummy) of Tut-ankhamûn.^{3, 4} These shrines are large, oblong,

¹ H. Stone, *The Timbers of Commerce*, p. 297.

² A. Lucas, 'Cedar'-tree Products employed in Mummification, in *Journal of Egyptian Archaeology*, xvii (1931), p. 14.

³ Howard Carter and A. C. Mace, *The Tomb of Tut-ankh-Amen*, I, pp. 180-3; Pl. XLV.

⁴ Howard Carter, *The Tomb of Tut-ankh-Amen*, II, pp. 31-3, 39-47; Pls. XII, XIII, XIV, XV, LIV, LVI, LVII, LVIII, LIX.

roofed wooden structures with a double door at one end and are covered, both inside and outside, with a thin coating of plaster (made of whiting and glue), which is decorated with funerary scenes and inscriptions and then thickly gilt, exceptions being the roofs of the two larger shrines, which are mostly coated with black varnish, and the outside of the largest shrine, which in addition to gold, is ornamented with blue faience. In the tomb, the shrines were placed one outside the other, the outermost, which practically filled the burial chamber, being about $16\frac{1}{2}$ feet (5 metres) long; 11 feet (3.3 metres) wide and, 9 feet (2.8 metres) high. Each shrine consists of a number of sections, which had been assembled in the tomb, and which had to be taken apart to remove them from the tomb, the larger sections or panels, being made of separate planks fastened together with wooden pegs, the sections being joined by means of tongues and grooves.¹ The wood is about $2\frac{1}{4}$ inches (57 mm.) thick. It was not possible to see any part of the bare wood until the shrines had been taken to pieces and then only some of the edges and parts of the tongues and, before any critical examination had been made, it became necessary to treat both surfaces of all the sections with melted paraffin wax in order to consolidate and preserve the gilt plaster, in doing which the wood of the edges of the sections and of the exposed parts of the tongues also became covered with wax, thus concealing its appearance. However, when the surplus wax was being removed (which was done by the author at the Cairo Museum by means of electrical heaters) a certain amount of examination was found possible and was made. This consisted of (a) a careful examination of all the exposed parts with the naked eye and with a lens² and the comparison of the wood with

¹ With few exceptions (chiefly corner-pieces) the tongues were not part of the planks, but had originally been entirely separate and loose, though when examined, some were found tightly wedged in. In most cases the tongues were wood, but in some instances they were of copper (analysed by the author and found to be free from tin and therefore not bronze). In many cases, too, the tongues, although of wood, were not of the same kind of wood as the planks. Altogether 177 tongues were critically examined, of which 107 (60 per cent) were cedar and 70 (40 per cent) were sidder (*nabk*). In the largest (outermost) shrine, out of 93 tongues examined, 47 were cedar and 46 sidder (*nabk*).

² After scraping off the wax.

small specimens previously taken from the shrines, sections of which had been examined microscopically by Dr. L. Chalk of the Imperial Forestry Institute, Oxford, and identified as cedar and sidder respectively, and (b) a microscopical examination of additional sections (prepared for the author in Germany), using Dr. Chalk's photomicrographs as standards, the sections having been taken from broken edges of the planks and from a large number of the tongues (many of these having been sawn off, either in the tomb to enable the sections to be taken apart, or to facilitate packing, or in the Museum to allow the sections to be fitted together when the shrines were being re-erected.)¹

The main wood of the shrines, so far as it has been examined, is cedar, but as much of it cannot be seen and never has been seen since the shrines were made more than 3,200 years ago, the nature of the part concealed naturally cannot be proved, though, judging both by analogy and probability, this, too, is cedar.

The wooden tongues are of two very distinct kinds, which differ considerably in appearance and thickness, one being light-brown with characteristic darker reddish-brown markings, which varies in thickness from about 0.67 inch (17 mm.) to about 0.79 inch (20 mm.), and the other being of a uniform and different shade of brown without conspicuous markings and much thinner, being only from about 0.23 inch (6 mm.) to about 0.39 inch (10 mm.). The former is cedar and the latter is sidder (*nabk*).

The matter will be discussed further in connexion with both oak and sidder.²

Cypress

Although a few specimens of the cypress tree *Cupressus sempervirens*) are grown in gardens in the Delta at the present day, the cypress is not an Egyptian tree and probably was not introduced into the country until modern times; it grows, however, plentifully in both southern Europe and western Asia. Since

¹ In the case of the largest shrine, there were so many tongues broken and missing that these had to be replaced before the shrine could be erected, which was done with new tongues of beech wood.

² See pp. 383, 390.

the wood of predynastic date identified as probably cypress was found at the same place as some cedar, which is a typically Syrian tree, that particular piece of cypress had probably been imported from Syria and, therefore, possibly also the later specimens. The Third Dynasty specimen was from a 6-ply wooden coffin found in the step pyramid at Saqqâra.¹

Fir

Two of the specimens of fir examined are stated to be probably the Cilician fir (*Abies cilicica*), which grows in Asia Minor and Syria. The species of the third specimen could not be determined.

Juniper

The juniper, of which there are a number of different species, is a tree with a fragrant red wood, which is, and apparently always has been confused with the cedar and was so confused by the Greeks² and Romans.² The particular species of juniper represented by the specimens could not be determined with certainty, though in the case of that from the Third Dynasty, which was from the plywood coffin found at Saqqâra¹ it is suggested that it may be *Juniperus phœnicea*.

The juniper is very plentiful on the Syrian mountains, but it is found also in Asia Minor. From inquiries made there would seem to be in Syria at the present time only one kind of juniper (*J. excelsa*) that grows to the dimensions of a tree, which it is stated may reach a height of between 60 and 70 feet (about 20 metres), the other kinds of juniper being only bushes.

Lime

The lime tree is a native of middle and southern Europe, from where the wood might easily have reached Egypt. In

¹ J. P. Lauer, *Fouilles du Service des Antiquités à Saqqarah*, in *Annales du Service*, xxxiii (1933), pp. 163-5; Fig. 5; Pl. II.

² A. Lucas, 'Cedar'-tree Products employed in Mummification, in *Journal of Egyptian Archaeology*, xvii (1931), pp. 13-21.

view, however, of the identification by Newberry¹ of two flowers of *tilia europaea* (fragile and short lived objects that are most unlikely to have been imported) among the vegetable remains from the Ptolemaic cemetery at Hawara, it seems probable that one or more examples of the tree may have been cultivated in the Fayûm province of Egypt at a late period and, therefore, that the small piece of wood examined (a mummy label) may have been of local origin.

Oak

Mr. L. A. Boodle, formerly of the Jodrell Laboratory, Royal Botanic Gardens, Kew, identified a specimen of wood from the large gilt shrines that enclosed the sarcophagus of Tut-ankhamûn, as oak.² The author, who worked with Dr. Howard Carter at Luxor one winter for about three months on the preservation of these shrines and alone for about five months at the Cairo Museum the following winter, examined critically all the wood of the shrines that was accessible and could only find two kinds, one (cedar) employed for the main parts of the shrines and for many of the tongues³ and a second (sidder) used only for tongues.³

Pine

The specimens of pine wood from ancient Egypt that have been found up to the present are two only, one a trimmed piece of predynastic date and the other from the Third Dynasty plywood coffin found in the step pyramid at Saqqâra.⁴ The species of the earlier specimen could not be determined, but that from

¹ P. E. Newberry, *The Ancient Botany*, in *Kahun, Gurob and Hawara*, W. M. Flinders Petrie, p. 46.

² Howard Carter, *The Tomb of Tut-ankh-Amen*, II, p. 39; III, p. 153. Whether this specimen was taken from the planks or from one of the tongues is not stated, but probably from a tongue.

³ See pp. 379, 390. In August, 1932, the author notified Mr. Boodle of these results and sent him specimens of the two kinds of wood. Mr. Boodle replied very briefly that he was then occupied with the determination of the wood found in the tomb of Tut-ankhamûn, including that of the great shrines, but he did not discuss the matter, so up to the present the discrepancy has not been cleared up.

⁴ J. P. Lauer, *op. cit.*, pp. 163-5; Fig. 5; Pl. II.

the Third Dynasty is probably *Pinus halepensis*. As the pre-dynastic specimen was found at the same place as some pieces of cedar, a typically Syrian tree, probably it, too, had been brought from Syria, though the pine also grows in Asia Minor and *Pinus balpensis* (the Aleppo or Jerusalem pine) is the commonest pine in the Mediterranean region.

Yew

The common yew (*Taxus baccata*) grows both in western Asia and in southern Europe, but it was probably from Asia and possibly from the Taurus Mountains that the specimens of this wood found in Egypt were brought, all of which were of fairly early date, two being from the Sixth to Twelfth Dynasty and the third from the Eighteenth Dynasty.

The yew is remarkable among conifers for the absence of resin and, therefore, it cannot possibly be the ancient *âsh*, as suggested by Ducros,¹ the resin from which was as important as the wood.

Ebony

Whatever difficulties there may be in the recognition of most of the kinds of wood imported into Egypt, there are none with respect to ebony, the ancient Egyptian name (*hebeny*) being well known and the wood, on account of its characteristic colour and appearance, being readily recognized without microscopical examination.

In the ancient Egyptian records ebony is stated to have been obtained from Genebteyew,² Kush,³ Negro Lands,⁴ Nubia,⁵ Punt⁶ and the South Countries,⁷ all of which are situated to the south of Egypt. This does not mean that ebony grew in all these places, but merely that it reached Egypt from the south. Even at the beginning of last century, small logs of ebony, about a foot in length, were articles of trade at Shendi,⁸ which is situated a little north of Khartum.

Herodotus states⁹ that ebony was an article of tribute from

¹ H. A. Ducros, *Annales du Service*, xiv (1914), pp. 1-12.

² J. H. Breasted, *op. cit.*, II, 474. ³ II, 494, 502, 514.

⁴ I, 336. ⁵ II, 375. ⁶ II, 265, 272, 486. ⁷ II, 652.

⁸ J. L. Burckhardt, *Travels in Nubia*, p. 280. ⁹ III, 97.

Ethiopia, Diodorus¹ and Strabo² both say that ebony trees grew in Ethiopia, but Pliny, commenting upon the statement of Herodotus, throws doubt upon its accuracy³ and in a later book states⁴ that the ebony tree did not grow in Egypt, in which term apparently he included Ethiopia.

What is ordinarily called ebony is the black heart wood of a number of different kinds of tropical trees, at the present time the true ebony of commerce being the wood of *Diospyros ebenum*, which grows in southern India and Ceylon. As, however, the word ebony is derived from the ancient Egyptian *hebeny*, the original ebony was that known in ancient Egypt, which has been identified as the wood of *Dalbergia melanoxylon*,⁵ a tree that grows in tropical Africa. A specimen of ebony of Fifth Dynasty date examined by Wittmack is stated to be *Diospyros ebenum*.⁶ But as it seems most improbable that ebony should have been obtained from India or Ceylon at such an early period, and as it is difficult to be sure of the species from an examination of the dead wood, this identification needs confirmation before it can be accepted.

Mention is made in the ancient records⁷ of (a) the employment of ebony in Egypt for making chests, coffins, a harp and shrines; (b) a shrine, statues, staves and whips of ebony, though whether made in the country or not is not stated; and (c) ebony chairs and ebony statues as spoils of war. Most of these kinds of objects, except coffins and harps, have been found in graves, the statues, however, being very small. In the tomb of Tut-ankhamûn the ebony objects included a bed, bolts for shrine doors, a chair and the legs of a second one, the framework of boxes, a stand for a gaming board, a stool and veneer and inlay.^{8, 9}

One great use of ebony in Egypt was as veneer and inlay (generally in conjunction with ivory) for the ornamentation of furniture, boxes and other objects.

¹ I, 3.² XVII, 2, 2.³ XII, 8.⁴ XXIV, 52.⁵ G. Beauvisage, *Le bois d'ébène*, in *Recueil de travaux*, XIX (1897), pp. 77-83.⁶ L. Borchardt, *Das Grabdenkmal des Königs Nefer-ir-ke-Re*, p. 68.⁷ J. H. Breasted, *op. cit.*, v (Index), p. 121.⁸ Howard Carter and A. C. Mace, *The Tomb of Tut-ankh-Amen*, I, pp. 113, 114, 115, 119, 203.⁹ Howard Carter, *The Tomb of Tut-ankh-Amen*, II, pp. 31, 33; III, pp. 130, 232.

Small ebony objects (tablets and a cylinder seal) are known from the First Dynasty,¹ though the first mention of the wood that can be traced is in the Sixth Dynasty.²

EGYPTIAN TIMBER

Trees are often depicted on the walls of tombs and temples, but they are usually drawn in so conventional a manner that only very few can be recognized with certainty, namely, the acacia,³ the date palm, the dôm palm and the sycamore fig. The principal trees that grew in Egypt in dynastic times of which the timber was employed by the carpenter and joiner were acacia, sycamore fig and tamarisk, though the wood of other trees was also sometimes used, especially that of the date palm, the dôm palm, the sidder (*nabk*), the persea and the willow. The following list shows all the recent identifications by modern methods of Egyptian woods that can be traced :

Wood	Date	Object
Acacia . . .	Badarian period . . .	Log ⁴
Acacia . . .	About IIIrd Dynasty . . .	Beam ⁵
Acacia . . .	Vth Dynasty . . .	Tree trunk ⁶
Acacia . . .	VIth to XIIth Dynasty . . .	Coffin peg ⁷
Acacia . . .	XIIth Dynasty . . .	Coffin peg ⁸
Acacia . . .	XVIIIth Dynasty . . .	Two pegs ⁹
Acacia . . .	Ist century B.C. (?) . . .	Boning rod ¹⁰
Acacia . . .	Late . . .	Peg from box ⁵
Acacia . . .	Roman . . .	Mummy label ⁵
Persea . . .	New Kingdom . . .	Head-rest ⁵

¹ W. M. Flinders Petrie, (a) *The Royal Tombs of the First Dynasty*, I, pp. 11, 22, 40; (b) *The Royal Tombs of the Earliest Dynasties*, II, p. 22.

² J. H. Breasted, *op. cit.*, I, 336.

³ An excellent representation of an acacia tree occurs in a Twelfth Dynasty tomb at Beni Hasan (F. Ll. Griffith, *Beni Hasan*, IV, Frontispiece).

⁴ G. Brunton and G. Caton-Thompson, *The Badarian Civilisation*, p. 95.

⁵ W. Ribstein, *ibid.*

⁶ L. Borchardt, *Das Grabdenkmal des Königs Nefer-ir-ke-Re*, p. 43.

⁷ G. Beauvisage, *Recueil de travaux*, XVIII (1896), p. 85.

⁸ M. A. Murray, *The Tomb of Two Brothers*, p. 11.

⁹ L. Borchardt, *Der Porträtkopf der Königen Teje*, p. 11.

¹⁰ K. P. Oakley, *The Analyst*, LVII (1932), p. 159.

Wood	Date	Object
Sidder (<i>Nabk</i>) .	XVIIIth Dynasty (Tut-ankhamûn)	Shrines (tongues) ¹
Sidder (<i>Nabk</i>) .	XVIIIth Dynasty (Queen Tyi) .	Shrines (tongues) ²
Sidder (<i>Nabk</i>) .	Roman	Mummy label ³
Sidder (<i>Nabk</i>) .	Undated	Peg ³
Sycamore fig .	Vth Dynasty	Vases ⁴
Sycamore fig .	XIth Dynasty	Roots ⁵
Sycamore fig .	XIIth Dynasty	Coffins ⁶
Sycamore fig .	Probably XIIth Dynasty	Coffin ⁷
Sycamore fig .	XIIth Dynasty	Coffin ⁸
Sycamore fig .	XIIth Dynasty	Statuette ⁸
Sycamore fig .	XVIIIth Dynasty	Model building cradles ⁸
Sycamore fig .	XXth to XXVIth Dynasty	Coffin ¹
Sycamore fig .	Very late	Eight specimens ³
Tamarisk .	Late Quaternary period	Stems and branches ⁹
Tamarisk .	Badarian period	Pieces ¹⁰
Tamarisk .	Predynastic period	Pieces ¹¹
Tamarisk .	XIth Dynasty	Roots ⁵
Tamarisk .	XXth to XXVIth Dynasty	Coffin pegs ¹
Tamarisk .	XXth to XXVIth Dynasty	Coffin ¹
Tamarisk .	Roman	Five specimens ³
Willow .	Protohistoric	Knife handle ¹²
Willow .	Third Dynasty	Box ³
Willow .	Greek	Tent pole ¹³
Willow .	Roman	Mummy label ³

The various woods mentioned may now separately be considered.

¹ Several specimens kindly identified for the author by Dr. L. Chalk (The Imperial Forestry Institute, University of Oxford, *Eighth Annual Report*, 1931-2, p. 11); a number of other specimens identified by the author.

² Kindly identified for the author by Dr. L. Chalk.

³ W. Ribstein, *ibid.*

⁴ L. Borchardt, *Das Grabdenkmal des Königs Nefer-ir-ke-Re*, pp. 60-2.

⁵ H. E. Winlock, *The Egyptian Expedition, 1921-1922*, *Bull. Met. Mus. of Art*, New York, II (1922), pp. 26-8.

⁶ M. A. Murray, *The Tomb of Two Brothers*, p. 11.

⁷ G. Beauvisage, *Annales de la Société botanique de Lyon*, XX (1895), p. 2.

⁸ K. P. Oakley, *The Analyst*, LVII (1932), p. 159.

⁹ K. S. Sandford, *The Pliocene and Pleistocene Deposits of Wadi Qena*, in *Quart. Journ. Geological Society*, LXXXV (1929), p. 503.

¹⁰ G. Brunton and G. Caton-Thompson, *op. cit.*, p. 38. ¹¹ *Id.*, p. 62.

¹² G. Mollers and A. Scharff, *Das vorgeschichtliche Graberfeld von Abusir El-Meleq*, p. 47.

¹³ C. C. Edgar, *Zenon Papyri*, III (1928), *Cat. Gén. du Musée du Caire*, No. 59253, pp. 80-1.

Acacia

A number of different varieties of acacia grow in Egypt and the wood has been identified as having been used as early as the Badarian period.

Acacia is mentioned in the ancient records as having been obtained in the Sixth Dynasty from Hatnub ¹ in Middle Egypt and from Watwat ² in Nubia and to have been used for making boats ^{1, 2, 3} and warships.⁴ Herodotus states ⁵ that acacia wood was employed in Egypt, not only for boat building, but also for the masts; Theophrastus says ⁶ that the acacia was an Egyptian tree used for roofing and for the ribs of ships; Strabo refers ⁷ to the Thebaic acacia and Pliny, apparently quoting Theophrastus, mentions ⁸ an Egyptian thorn, evidently the acacia from the description, that was used for making the sides of ships, which tree he states grew in the vicinity of Thebes. Acacia is still used in Egypt for boat building as well as for other purposes.

Date Palm

The date palm (*Phoenix dactylifera*) has been cultivated in Egypt from very remote times and is often represented on tomb walls, for example, in a number of Eighteenth Dynasty tombs in the Theban necropolis and in the Punt scenes on the mortuary temple of Hatshepsût at El-Deir el-Bahari.

The wood of the date palm, on account of its loose fibrous texture, is quite unsuitable for joiners' work, but the split trunk of the tree was employed anciently for roofing, as it still is occasionally at the present day, since a tomb of the Second or Third Dynasty at Saqqâra was roofed with palm logs⁹; in a tomb of early date at Qâw¹⁰ near Asyût, in a Fourth Dynasty tomb adjoining the pyramid of Chephren and in the Fifth Dynasty tomb of Ptahhotep at Saqqâra a roof of this kind has been copied in stone. In the Græco-Roman city of

¹ J. H. Breasted, *op. cit.*, I, 323.

² I, 324.

³ IV, 229, 283, 387, 916, 1023.

⁴ IV, 229, 387.

⁵ II, 96.

⁶ IV, 2, I, 8.

⁷ XVII, I, 35.

⁸ XIII, 19.

⁹ J. E. Quibell, *Excavations at Saqqara (1912-1914)*, p. 21.

¹⁰ Villiers Stuart, *The Funeral Tent of an Egyptian Queen*, p. 83.

Keranis in the Fayûm palm wood was occasionally employed in the houses.¹

Miss Caton-Thompson and Miss Gardner found fruit stones of a wild date (*Phœnix sylvestris*) of early Upper Paleolithic times in a deposit of late Pleistocene age in the Kharga Oasis.²

Dôm Palm

The dôm palm (*Hyphæne thebaica*) is represented in an unmistakable manner in several Eighteenth Dynasty tombs in the Theban necropolis. Theophrastus, who states that the dôm palm was an Egyptian tree,³ comments upon the characteristic bifurcation of the trunk, which he contrasts with the undivided trunk of the date palm; he describes the wood as being very compact and hard and, therefore, very different from that of the date palm, and states that it was employed by the Persians for making the feet of couches. Delile states⁴ that the wood was used in Egypt at the time he wrote (1809) for making doors and, probably, therefore, it was sometimes employed anciently by the carpenter and joiner.

The dôm palm still grows in Egypt, from about Abydos southwards and the fruit has been found in graves as early as the predynastic period.⁵

Persea

The persea tree (*Mimusops Schimperi*) is referred to in the ancient records from the Eighteenth Dynasty onwards^{6, 7} and is mentioned by several of the classical writers. Thus Theophrastus⁸ describes it as an Egyptian tree that grew in abundance in the Thebaid; he states that it was evergreen (which it is) and that the wood, which was strong and black, like that

¹ A. E. R. Boak and E. E. Peterson, *Karanis*, p. 52.

² G. Caton-Thompson and E. W. Gardner, *The Prehistoric Geography of Kharga Oasis*, in *The Geographical Journal*, LXXX (1932), p. 384.

³ IV, 2, 7.

⁴ M. Delile, in *Description de l'Égypte, Histoire Naturelle*, I (1809), p. 54.

⁵ G. Brunton and G. Caton-Thompson, *The Badarian Civilisation*, p. 63.

⁶ J. H. Breasted, *op. cit.*, II, 298; IV, 288, 385.

⁷ A. Erman, *The Literature of the Ancient Egyptians*, trans. A. M. Blackman, pp. 159, 160, 246.

⁸ IV, 2, 1, 5, 8.

of the nettle tree, was used for making images, beds, tables and other objects. The author fortunately had an opportunity of examining this wood when a persea tree, planted by Schweinfurth in the garden of the Cairo Museum, was being trimmed, and found that it was very light brown, almost white, in colour with a very slight yellowish tint and that, although it darkened a little on exposure, it did not become more than brown. Diodorus¹ refers to a tree that grew in Egypt, which he calls the *persica* (peach), which was probably the persea; Strabo² says that the persea was an Ethiopian tree and Pliny³ states that it was an Egyptian tree and he mentions a confusion existing in his day between the persea and the *persica*.

Twigs and leaves of persea have been found in tombs of various dates from the Twelfth Dynasty⁴ to Græco Roman times and in the tomb of Tut-ankhamûn (Eighteenth Dynasty) there were bouquets (several very large) made of twigs with leaves,^{5, 6} also dried fruit and two glass models of the fruit. Other examples from this same dynasty are also known.^{7, 8} The head-rest identified by Ribstein as being made of persea wood was of New Kingdom date.

Sidder

As there are various species of sidder, and as it is impossible to be absolutely certain of a species from a microscopical examination of the wood alone, the specimens found to be sidder may be one of several kinds, though from collateral evidence they are practically certainly either *Zizyphus mucronata* or *Zizyphus spina Christi* and probably the latter.

The first of the two sidders mentioned (*Z. mucronata*) is very widespread in Africa, being common all over the drier parts of tropical and south Africa, including the Sudan, and, therefore, it might have been used in ancient Egypt, though this seems

¹ I, 3.

² XVII, 2, 2, 4.

³ XIII, 17; XV, 13.

⁴ P. E. Newberry, *Extracts from my Notebooks*, in *Proc. Soc. Bibl. Arch.*, XXI (1899), p. 304.

⁵ Howard Carter and A. C. Mace, *The Tomb of Tut-ankh-Amen*, I, Pl. XXVII.

⁶ Howard Carter, *The Tomb of Tut-ankh-Amen*, II, p. 33.

⁷ H. E. Winlock, *The Tomb of Meryet-Amûn at Thebes*, p. 62.

⁸ E. Schiaparelli, *op. cit.*, II, p. 166.

improbable, unless it then grew in the country, for which there is no evidence, since the only woods that were brought into Egypt from the south, of which there are records, were ebony and certain sweet and fragrant woods, probably for use as incense or for making perfumed ointments. The second species of sidder mentioned (*Z. spina Christi*) grows in the Mediterranean region generally, including Egypt, where it is indigenous, and possibly also in tropical Africa.¹ In Egypt it is called the *nabk*, although strictly this is the name of the fruit and not of the tree. The fruit is about the size of a small cherry and not unlike a yellowish-coloured cherry in appearance and it has one stone, not unlike a cherry stone in size and shape. The dried fruit is known in Egypt from predynastic times² and has often been found in tombs. This tree, although not large enough to have provided the planks that formed the main parts of the shrines mentioned (those of Tut-ankhamûn and Queen Tyi respectively) is sufficiently large to have been used for tongues and, as it grows in the country and is a good hard durable wood, it is not unlikely, if the amount of cedar available were not sufficient for all the tongues, that the local sidder should have been used for the remainder.

Hamilton states³ that the timber of the *nabk* 'is one of the most serviceable in Egypt, the greater part of the Persian water wheel being made of it,' and as the wood has been found so useful in modern times, it is only reasonable to suppose that it was also employed anciently.

Sycamore Fig

The sycamore⁴ fig (*Ficus sycomorus*) which is often called the sycamore and is the sycamore of the Bible, has no connexion with the sycamore of colder climates, which latter is a species of maple (*Acer pseudo-platanus*).

The sycamore fig is frequently referred to in the ancient

¹ W. G. Browne (*Travels in Africa, Egypt and Syria*, 1799, p. 270) states that he found two species of sidder in Darfûr, one of which appeared to be the same that he had seen in Alexandria.

² W. M. Flinders Petrie, *Prehistoric Egypt*, p. 44.

³ W. Hamilton, *Remarks on Several Parts of Turkey*, I, *Ægyptiaca*, 1809, p. 71.

⁴ The New Oxford Dictionary states that the spelling sycamore is more usual than sycomore.

Egyptian records, thus in the Eighteenth Dynasty sycamore wood to be used for building a boat is mentioned,¹ and in the Twentieth Dynasty statues of the wood² and sycamore gardens³ are also mentioned. The tree is frequently represented on tomb walls of the Eighteenth Dynasty at Thebes.

Diodorus⁴ refers to the sycamore, which he calls the Egyptian fig tree, as growing in Egypt; Theophrastus⁵ also describes the sycamore as an Egyptian tree and says that the wood was useful for many purposes; Strabo⁶ states that it grew in Ethiopia and Pliny,⁷ who quotes Theophrastus, also calls the sycamore the Egyptian fig and states that the wood was among the most useful known.

Either the wood or the fruit of the sycamore fig (which of the two is not stated) has been found in graves as early as the predynastic period⁸ and the fruit from the First Dynasty⁹; in the Cairo Museum there are six readily recognized models of the sycamore fig tree in a miniature garden of the Eleventh Dynasty, found by Winlock at Thebes, and Winlock also discovered roots of this same tree in the courtyard of the Eleventh Dynasty temple of Mentuhotep at El-Deir el-Bahari¹⁰; in the Cairo Museum there is a twig with leaves of Twentieth Dynasty date and, as will be seen from the list given, the wood has been identified in objects varying in date from the Fifth Dynasty to a very late period. The tree still grows plentifully in the country.

Tamarisk

The tamarisk tree, of which there are many species in Egypt, is manifestly indigenous to the country since semi-carbonized stems and branches of considerable size have been found by Sandford in the Wâdi Qena,¹¹ which he attributes to late Quater-

¹ J. H. Breasted, *op. cit.*, II, 326.

² IV, 303, 349, 395.

³ IV, 380.

⁴ I, 3.

⁵ IV, 2, 1, 2.

⁶ XVII, 2, 4.

⁷ XII, 14.

⁸ W. M. Flinders Petrie and J. E. Quibell, *Nagada and Ballas*, p. 54.

⁹ W. M. Flinders Petrie, *The Royal Tombs of the Earliest Dynasties*, II, pp. 36, 38.

¹⁰ H. E. Winlock, *Bull. Met. Mus. of Art, New York*, II (1922), pp. 26, 28.

¹¹ K. S. Sandford, *The Pliocene and Pleistocene Deposits of Wadi Qena*, in *Quart. Journal, Geological Society*, LXXXV (1929), p. 503.

nary times, and tamarisk wood has been identified from the neolithic,¹ the Badarian² and the predynastic² periods respectively.

The tamarisk is occasionally mentioned in the ancient records from the pyramid age onwards³ and bundles of tamarisk wood are referred to in the Twentieth Dynasty.⁴ Herodotus states⁵ that certain rafts used in connexion with boats were of tamarisk.

Winlock found evidence to show that a grove of tamarisk trees once existed in front of the Eleventh Dynasty temple of Mentuhotep at El-Deir el-Bahari ;⁶ the tree still grows plentifully in the country.

Willow

The Egyptian willow tree (*Salix safsaf*),⁷ whether indigenous or not in the country, is manifestly of considerable antiquity, as the handle of a flint knife of protohistoric date has been identified as willow, another example of its early use being for a box of the Third Dynasty ; it was also employed during Græco-Roman times and is still utilized for making camel saddles, the screw of the Archimedian water elevator and for vine supports.⁸ Leaves of the willow tree of Eighteenth and Twenty-first Dynasty date respectively used for making funerary garlands are in the Cairo Museum.

WOOD WORKING

Although the log of acacia of Badarian date found by Brunton proves that wood was used before copper tools were available,⁹ it was not until the advent of such tools in the late predynastic period that wood working on more than a very small scale

¹ G. Caton-Thompson, *The Neolithic Industry of the Northern Fayum Desert*, in *Journal, Royal Anthropol. Institute*, LVI (1926), p. 314, n. 2.

² G. Brunton and G. Caton-Thompson, *op. cit.*, pp. 38, 62.

³ A. Erman, *op. cit.*, pp. 3, 18.

⁴ J. H. Breasted, *op. cit.*, IV, 241, 379, 392.

⁵ II, 96.

⁶ H. E. Winlock, *op. cit.*, pp. 26, 27.

⁷ This tree has recently been made the subject of a special study by Dr. L. Keimer (*Bull. de l'Inst. français d'archéol. orientale*, XXXI (1931), pp. 178-227.

⁸ Kindly communicated by Professor F. W. Oliver, F.R.S.

⁹ Copper was not entirely unknown at this date, but was not used for tools.

and in a very crude manner was possible and the few specimens of wood of predynastic date, also found by Brunton (which were probably of Syrian origin) may have been either sufficiently late to have fallen within 'the copper tool period' or they may have been worked only in the rough manner that alone was possible without copper tools.

The tools employed in ancient Egypt by the carpenter and joiner are well known, both from illustrations of their use pictured on tomb walls and from miniature specimens found in tombs. They were adzes, axes, bow-drills, chisels (some used with a mallet) and saws. The illustrations of wood working occur in a Fifth Dynasty tomb at Saqqâra¹; in a Twelfth Dynasty tomb at Deir el-Gabrâwi²; in two Twelfth Dynasty tombs at Beni Hasan^{3, 4} and in three Eighteenth Dynasty tombs at Thebes,^{5, 6} and in the Cairo Museum there are two tomb models of a carpenter's workshop with miniature specimens of the tools, which are of copper with wooden handles and which are identical with those pictured in the tombs. One of these models is of Eleventh Dynasty date from Thebes and the other, which is undated, is from Saqqâra.

As an example of skilled wood carving at an early date, the Fifth Dynasty wooden statue called the 'Sheikh el-Balad' may be cited; incidentally it may be mentioned that the eyes are inlaid, the rim being copper, the white of the eyeball opaque quartz, and the cornea transparent quartz (rock crystal) with the pupil represented by means of a small circular hole at the back of the cornea filled in with a black material. As examples of skilled joiner's work attention may be drawn to the following named: (a) the carrying chair, the bed, the arm-chair and several boxes found in Fourth Dynasty tomb of Hetepheres,⁷ at which date mortise and tenon joints were being used; (b)

¹ G. Steindorff, *Das Grab des Ti*, Pls. 119, 120, 132, 133.

² N. de G. Davies, *The Rock Tombs of Deir el Gebrawi*, I, Pls. XIV, XV, XVI.

³ P. E. Newberry, *Beni Hasan*, I, Pl. XXIX. ⁴ *Id.*, II, Pl. XIII.

⁵ P. E. Newberry, *The Life of Rekhmara*, Pls. XVII, XVIII.

⁶ N. de G. Davies, (a) *The Tomb of Two Sculptors at Thebes*, Pl. XIII; (b) *The Tomb of Nefer-hotep at Thebes*, I, Pls. V, XXVI, XXVII, XLVII, XLIX.

⁷ G. A. Reisner, *Bull. Mus. of Fine Arts, Boston*, xxv (1927), Supplement; xxvi (1928), No. 157; xxx (1932), No. 180. The present wood is entirely new, but it only replaces old wood that had perished.

the Twelfth Dynasty inlaid caskets from Lahun¹; (c) the furniture from the Eighteenth Dynasty tomb of Yuya and Thuyu; and (d) the furniture from the tomb of Tut-ankhamûn,^{2,3} which shows the use of mortise and tenon joints, dovetailing, wooden pegs and metal rivets (silver with gold heads), which latter were employed for fastening the lid of a wooden coffin to the body of the coffin, and ebony and ivory inlay and veneer.

SILICIFIED WOOD

Silicified, or petrified, wood is wood the original substance of which has been removed by natural agencies and replaced by silica in such a manner that the structure of the wood has been preserved. Silicified wood occurs plentifully in Egypt and is widely distributed, being found near Cairo, in both the eastern and western deserts, in the Fayûm and in Sinai. Although very hard, this material was occasionally employed for carving and a statuette of it from the Nineteenth Dynasty⁴ is in the Cairo Museum and Petrie mentions a scarab of silicified wood, possibly also of Nineteenth Dynasty date.⁵ A grinder of this wood is known from the neolithic period⁶ and a worked fragment of the Badarian period.⁷

The genera and species of much of this silicified wood have been determined,^{8, 9, 10} but it is unnecessary to quote them here, since none of the kinds of wood are known from historical times.

¹ A. C. Mace, *The Lahun Caskets*, in *Ancient Egypt*, 1921, pp. 4-6.

² Howard Carter and A. C. Mace, *The Tomb of Tut-ankh-Amen*, I.

³ Howard Carter, *The Tomb of Tut-ankh-Amen*, II and III.

⁴ G. Legrain, *Statues et Statuettes*, Cat. Gén. du Musée du Caire, I, pp. 55-6; Pls. LX, LXI.

⁵ W. M. Flinders Petrie, *Scarabs and Cylinders with Names*, p. 9.

⁶ G. Caton-Thompson, *The Neolithic Industry of the Northern Fayum Desert*, in *Journal, Royal Anthropol. Inst.*, LVI (1926), pp. 312, 315.

⁷ G. Brunton and G. Caton-Thompson, *The Badarian Civilisation*, p. 102.

⁸ F. Unger, *Der Versteinerte Wald bei Cairo*, 1858.

⁹ Krauss and Schenk, quoted by Barron (*The Top. and Geol. of the District between Cairo and Suez*, p. 58).

¹⁰ F. W. Oliver, *Oasis Impressions*, in *Trans. Norfolk and Norwich Naturalists Society*, XIII (1930-1), p. 176.

CHARCOAL

Charcoal, which may conveniently be dealt with in connexion with wood, was until comparatively recently, when it was largely displaced by paraffin oil (kerosene), the principal fuel of Egypt and it is still much used.

At one time charcoal-burning was extensively carried out in the eastern desert and in Sinai, in both of which localities it still lingers on, though to a very limited extent, and it is this industry that has been largely responsible for the destruction of trees in these districts.

Charcoal has often been found in connexion with ancient Egypt, for example in a First Dynasty tomb at Saqqâra¹; in two of the store rooms of the pyramid temple of Mycerinus (Fourth Dynasty)² and in early dynastic tombs at Naga el-Deir³ and it is mentioned as being distributed to the masons who cut the corridors of one of the royal tombs in the Valley of the Tombs of the Kings.⁴

¹ J. E. Quibell, *Excavations at Saqqara (1912-1914)*, p. 15.

² G. A. Reisner, *Mycerinus*, p. 238.

³ G. A. Reisner, *A Provincial Cemetery of the Pyramid Age, Naga-ed-Der*, III, p. 157.

⁴ On an ostrakon (No. J. 33857) of Twentieth Dynasty date in the Cairo Museum.

ADDENDUM

Additional reference to the use of foreign woods in ancient Egypt:
H. Schäfer, *Armenisches Holz in altägyptischen Wagnereien*, Berlin, 1931.

CHAPTER XV

HISTORICAL SUMMARY¹

From what is known about a people, to trace their gradual growth from a primitive state to one of advanced civilization is a task for the historian, and the author has no intention of trespassing in this matter, but he hopes he may be pardoned if he endeavours to piece together, very briefly and in a very elementary manner, the most important of the facts he has recorded and to give some little indication of their bearing upon the condition of the ancient Egyptians and upon their intercourse with other nations.

Ancient Egyptian history, like that of many other countries, may roughly be divided into a Stone Age, a Copper Age,² a Bronze Age, and an Iron Age, each in turn gradually giving place to the next. The distinguishing feature of these several periods was not the mere employment of stone, copper, bronze, or iron, as the case might be, since each of these was employed in all the succeeding periods and was even known as a curiosity and occasionally used in the preceding period, but it consisted in the use of the special material, after which it is named, for weapons and tools.

Up to the present time fossil remains of primitive man have not been discovered in Egypt, neither remains of the earlier stages of his development when he was merely the genus *homo* (who probably dates back to the end of the Pliocene period or the beginning of the Pleistocene period, possibly a million years or so ago), nor remains of the later and finished stage of his physical evolution when he had become *homo sapiens* (who

¹ References previously given have not been repeated.

² To group the Egyptian Copper and Bronze Ages together and to call them both the Copper Age, as is sometimes done, is most misleading.

is much more recent and possibly not more than fifty thousand years or so old).

The first inhabitants of Egypt of which there is any knowledge were the Old-Stone Age or paleolithic people. Whence they came and the reason for their coming are both unknown, but that they must have originated outside Egypt is manifest unless Egypt is 'the cradle of the human race,' which is not suggested by anyone. Once in the country, however, abundant game and water and a pleasant climate would be sufficient reasons for their remaining.

'The Pleistocenc period during which Paleolithic Man hunted along the banks of the Nile and ranged over the surrounding hills and plateaus was a time of copious rainfall in Egypt. The dry wadis of the desert were running streams and the landscapes were pleasantly diversified with forest and grassland over which wandered troops of wild animals. Reaching far beyond its present bounds, the ancestral Nile flowed rapidly over a pebbly bed, augmented on its journey northward by a host of tributaries draining the surrounding country . . .'¹ a 'mighty Nile which then flowed high above its present level.'¹

Neither the habitations nor the graves of these people, if they had either, have been discovered, only large numbers of characteristic stone weapons and implements (mostly flint and chert) that have been found in various parts of the country. With these their owners could hunt and fight, and paleolithic man must have been essentially a hunter, depending largely for food on the animals he killed, supplemented by certain fruits, seeds (cereal grain) and roots he found growing wild: he was, therefore, a wanderer and a food gatherer and not a food producer, which means that he was not yet civilized.

The exact manner in which civilization developed in Egypt may never be known, but it seems probable that the first step towards it was taken when a community of the hunting paleolithic nomads (possibly at first only women and young children) settled down temporarily near the Nile and there discovered that a constant supply of the grain they were accustomed to gather in a haphazard manner, and which sometimes failed,

¹ K. S. Sandford and W. J. Arkell, *Paleolithic Man and the Nile Valley in Nubia and Upper Egypt*, p. xv.

might be assured by sowing, for almost certainly it was agriculture that first anchored man to one locality by making a permanent hunting life both unnecessary and impossible, thus paving the way for the arts and crafts that are essential to material civilization. All that would have been necessary to have started the ball of civilization rolling would have been for someone, either accidentally or intentionally, to have thrown ripe grain (barley or wheat)¹ on to a patch of mud left bare after the flood water of the river had subsided, and when the grain sprouted (which in Egypt would have been very soon after the sowing) to have realized that it was the direct result of the sowing and that never again need there be any shortage of food, since man had the power to grow it.

But since seeds were regularly falling on the ground and germinating wherever there were plants, and so producing an object lesson in the elements of agriculture, the artificial sowing of seed may surely have originated independently in more than one place and, if so, the initial Egyptian sowing may not have been the first in the history of the world, as suggested by Professor T. Cherry,² but merely an independent repetition of what had been done elsewhere under different conditions. Even imported knowledge of grain growing, though improbable, does not seem absolutely excluded, since the paleolithic hunters may have been in touch with kindred in the north, or they themselves may have ranged as far northward as Palestine and Syria, the north-east being the direction where other early civilizations arose.

The increase of population in Egypt ultimately and inevitably led to an extension of the natural irrigation system and land near the river not covered by the annual flood had water conducted to it by artificial channels. This however, would not have been needed until the settled population in any one district had outgrown the grain supply of the naturally-inundated land of that district, and a very long period may have elapsed between the earliest agriculture in Egypt and any attempt to extend artificially the area of cultivation.

¹ Both barley and wheat have been found in Egypt from the neolithic period, millet not being known until the predynastic period.

² T. Cherry, *The Discovery of Agriculture, in Proceedings of the Australian Association for the Advancement of Science*, 1921.

It is sometimes suggested that agriculture may have originated from the practice of either burying wild grain, such as barley, in graves, or of scattering it on the surface of newly-made graves. Though plausible and attractive, this is very improbable with respect to Egypt. Thus, in the neolithic settlement at Merimde, although grain was placed on the body to serve as food for the dead person, there is no record of this grain showing signs of having germinated and, even if exceptionally some of it had commenced to grow, the chance of the young plants reaching the surface of the ground would have been very small. At later periods, too, grain was sometimes placed in graves, but it was usually, if not always, in receptacles, such as baskets or pots, where it had no opportunity of germinating. At Merimde the dead were buried, not in special cemeteries, but among the buildings of the settlement, that is to say on high, dry ground and when later the burial was at a distance from the houses, in places set apart, these were never, so far as is known, in the inundated plain, but always on the edge of the dry desert and in such cases, any grain scattered on the surface of the graves would have stood a very poor chance of survival. It seems improbable, too, that 'graveyard tillage,' as it has been termed, could ever have led to an artificial irrigation system, such as is practised in Egypt and with which the early agriculture in the country seem inseparably bound up.

When once some of the nomad people had become settled in one place, even though at first only temporarily, needs would arise and could be satisfied that either were not felt before, or that were not previously capable of realization. Thus, shelters from the weather would be built; baskets and pots would be made as containers for grain and water respectively; sleeping mats would be plaited; clothing would be woven; food would be cooked; to the growing of grain would be added the growing of flax to make linen, and animals would be tamed and others would be bred in order to secure a constant supply of meat and skins, each advance, however, resulting in a loss of freedom, since hunting as a permanent whole-time occupation is incompatible with civilization. This is what actually did happen, the shadowy Old-Stone Age (paleolithic) people being succeeded (possibly before 10,000 B.C.) by the New-Stone Age or neolithic

Egyptians, who until recently were as unsubstantial as their predecessors, though their stone weapons and implements were of a more advanced type. Of these neolithic folk, settlements and cemeteries have been discovered during the last few years, which prove that, although still in the Stone Age, that is without any knowledge of metals, they were no longer merely food gatherers, but food producers and that they practised agriculture ; domesticated animals ; plaited baskets and mats ; wove fabrics ; made pottery ; made bone as well as stone implements ; made shell and stone beads and small stone vases, all of which connote some degree of civilization and a more or less settled mode of life.

Up to the present only a few neolithic sites have been excavated, of which the three principal are all near Cairo, one (in the Fayûm) on a lake about fifty miles to the south-west ; another (Merimde) about thirty miles to the north-west near the west bank of the river and the third (Helwan) about twenty miles to the south, also not far from the river, but on the east bank. The so-called ' Neolithic Site ' at Maadi near Cairo is not included, since according to the excavators ' The neolithic settlers at Maadi knew copper very well, and apparently possessed large quantities of it.'¹

This neolithic existence, doubtless slowly and steadily improving all the time, continued for several thousand years at least and then gradually and automatically came to an end as metals became known and as their use increased, the beginning of the knowledge of metals possibly dating from about 5000 B.C.

The use of metals (at the outset copper and gold) was naturally at first only very occasional and was confined to small articles of personal adornment, but later they were employed in greater quantity, gold always chiefly for ornament, and copper for weapons, tools and such household utensils as ewers, basins and dishes ; silver and lead also became known, though they were not used to any great extent until a very late period.

Although both copper and gold occur naturally in the metallic state, other things being equal, gold is the more likely to be discovered and used first, partly on account of its occurrence

¹ O. Menghin and M. Amer, *The Excavations of the Egyptian University in the Neolithic Site at Maadi*, p. 48.

in the form of glittering and attractive yellow particles and partly because of its great malleability, since it is readily shaped into simple ornaments. In Egypt, however, although gold occurred plentifully in certain localities and native copper very rarely, if at all, copper objects have been found of earlier date than those of gold, but the evidence is as yet so scanty that this does not necessarily mean that copper was used first (though this may have been so), since the earliest gold may not have been buried, or, if buried, the graves may have been robbed.

It has been suggested that the earliest copper known was always native metal and in certain places (notably special localities in North America) this was undoubtedly the case; but the use of native copper has not always, if ever, led to the method of producing it from ore and in Egypt there is no evidence whatever of native copper and no need to postulate either its existence or use, since a copper ore (malachite), from which the metal might easily have been obtained and from which it may be proved to have been obtained at an early period, was employed in large amount for painting round the eyes at a date not only as early as that of the use of the metal itself but probably earlier.

Malachite occurs in a number of different localities both in Sinai and in the eastern desert, in the latter of which no date can be fixed for mining before about the Twelfth Dynasty (about 2000 B.C.) but in Sinai there is definite proof of mining in the First Dynasty (before 3000 B.C.) which was either for copper ore or for turquoise (unfortunately it is not known which) and proof of mining for copper ore in the Old Kingdom (about 2980 B.C. to 2475 B.C.) of which period copper slag, chips of ore, broken crucibles and an ingot mould have been found and, since malachite (probably from Sinai) was employed in the Badarian and predynastic periods respectively, it seems likely that mining (which at first would consist merely in the extraction of ore from surface deposits and only later of excavation) dates from these periods. As some slight confirmation of the early date of the Sinai mining is the occurrence of a small proportion of manganese in copper objects of both the middle predynastic period and also of First or Second Dynasty date,¹

¹ Probably manganese would be found in other ancient Egyptian copper objects if search were made.

which seems to indicate that the ore from which the metal in these cases was derived had been obtained from Sinai, where there are abundant deposits of oxides of manganese in close proximity to the copper ore.

Since metallic copper may be produced from malachite by the very simple process of heating it in a wood or charcoal fire, it is highly probable that the first production of copper was by accident from this ore (the usual ore of surface deposits), the constant use of which would present innumerable opportunities for its accidental heating in such a manner that would produce a small quantity of the metal.

In the earliest graves in which copper has been found in Egypt it was in the form of small articles, such as beads, pins, rings and needles, and only in graves of later periods were there weapons and tools, that is to say, copper did not appear suddenly in a comparatively highly developed form as would be expected had it been imported, but all the stages of evolution from small and simple objects to larger and more complex ones have been found in proper sequence. This gradual increase in the amount of copper employed and the progressive improvement in the nature of the objects made, together with the very early use of malachite, would seem a strong indication that copper smelting may have been of Egyptian origin, but Frankfort, while admitting the facts does not admit the inference and says ¹ that 'history is no matter of logic, and comparative archaeology plainly proves that the opportunity was not grasped and that the use of copper on a considerable scale was due to Asiatic initiative.' The comparatively small amount of copper used in Egypt anciently and the not inconsiderable output of the Sinai and eastern desert mines are factors that frequently are not taken sufficiently into account in this matter. However, so much that was unknown and even unsuspected has been discovered during the past few years in Mesopotamia, India and elsewhere that manifestly finality in the knowledge of the various early civilizations has not yet been reached. It may be pointed out, too, that practically nothing is known about ancient copper mining and working in north Persia, or in the regions immediately south

¹ H. Frankfort, *Sumerians, Semites and the Origin of Copper-Working*, in *The Antiquaries Journal*, VIII (1928), p. 230, n. 1.

of the Caucasus Mountains between the Caspian Sea and the Black Sea, nor in the district south of the Black Sea, in all of which places copper ores are plentiful and in many of which there are ancient mines and slag heaps. Also, the Sumerian Copper Committee of the British Association has not yet concluded the inquiry into the origin of the copper used in southern Mesopotamia, where metallic ores do not occur, and neither has there been any systematic archæological investigation of the ancient Egyptian copper mines. A great deal, too, depends upon the correct dating of copper objects from different sources, about which there is still dispute. In view of these facts, it is not shirking the difficulty if the question of the origin of copper working be left unanswered for the present. Closely following and consequent upon the use of copper tools during the late predynastic period was the wonderful stone vase industry, which reached its zenith in the early dynastic period, and nowhere has there been found such a wealth of beautifully made, handsome stone vases as in Egypt, the stones employed including, not only the comparatively soft alabaster (calcite), but hard diorite, granite, quartz, schist and volcanic rock. Literally thousands of these vases (mostly broken) have been found in early dynastic tombs and in the step pyramid at Saqqâra, especially in the latter.¹ In the Third and Fourth Dynasties and the dynasties immediately following came the phenomenal working of stone for building pyramid-tombs and mortuary and other temples and the oldest and largest stone buildings in the world belong to this date. The hard stone statues, too, of this period have long been a source of wonder and admiration on account of their excellence.

One of the great landmarks in the history of civilization was the discovery of bronze, which displaced copper for many purposes, the Copper Age gradually giving place to the Bronze Age. This alloy, which is a mixture of copper and tin, was first made in western Asia and has been found in the Royal Cemetery at Ur, which is dated from about 3500 B.C. to about 3200 B.C., though bronze cannot have originated in southern Mesopotamia, since there are no metallic ores. Although there

¹ Those found in this pyramid alone are estimated to weigh more than 60 tons.

may have been, and probably were, a few sporadic importations of bronze into Egypt, possibly even as early as the Fourth Dynasty, it was not in general use until about the Twelfth Dynasty (about 2000 B.C.) from which period tools and other objects of bronze are known, and the Middle Kingdom, therefore, may be considered as the beginning of the Bronze Age in Egypt.

Whether bronze was ever made in Egypt, or whether the bronze objects found were fashioned from material imported into the country in the form of ingots, is uncertain, but since tin was known in Egypt in the Eighteenth Dynasty (a few objects of this metal and also a small quantity of artificial tin oxide from this period having been discovered) it seems probable that at least from this date onwards bronze was made locally from imported tin. At first the tin required was obtained from western Asia, possibly from near Byblos in Syria but later this source of supply seems to have failed, probably because the ore became exhausted, and tin then reached the eastern Mediterranean from western Europe (Brittany, Cornwall and Spain).

The Bronze Age in Egypt lasted about thirteen hundred years and was succeeded by the Iron Age. The earliest iron objects found in Egypt are a few small beads of predynastic date, the metal of which has been proved by chemical analysis to be of meteoric origin and, therefore, not made by man. Although this was possibly not the only instance of the utilization of meteoric iron by the ancient Egyptians, no others are known, and from the predynastic period until the end of the Eighteenth Dynasty only five specimens of iron objects have been discovered in the country, of which four are probably of later date than that assigned to them by their finders, thus leaving only one (now a mass of iron rust, but once possibly an iron object, adhering to copper adzes of Sixth Dynasty type) that has been tested and found not to be of meteoric origin, though it may have been merely a lump of iron smelted by accident and found to be useless because the method of working iron red-hot had not then been discovered. From the tomb of Tut-ankhamûn at the end of the Eighteenth Dynasty (about 1350 B.C.) there is an iron dagger (a gift to the king from western Asia) and a few very small typically Egyptian objects, almost certainly made in Egypt from a small lump of imported iron, probably

also a present from western Asia. After this there is a gradual increase in the number of iron objects known, but the first group of iron tools yet found dates from about 700 B.C., which may, therefore, be considered as the beginning of the Iron Age in Egypt.

The earliest iron smelting of which evidence has been found in Egypt was at Naucratis in the north-west of the Delta, about the sixth century B.C., but the source of the ore dealt with is not known. Iron ores, however, were mined anciently both in the eastern desert (possibly by the Romans) and also near Aswan.

At Gerar in southern Palestine, not very far beyond the eastern frontier of Egypt, a large number of iron weapons, tools and implements have been found, the dates of which are stated by Petrie to range from about 1300 B.C. to about 600 B.C., and also four iron-smelting furnaces, which show that the metal employed was produced locally from ore and not imported.¹ The home of iron working, however, was not in Palestine, but farther north, though whether in Asia Minor or in the Caucasus region there is not yet sufficient evidence to show.

The first production of iron was almost certainly an accident, possibly due to the use by mistake of iron ore in place of copper ore and there cannot be any doubt that when first obtained the metal was treated in the same manner as copper and bronze in order to shape it, namely by hammering it cold, which naturally was found to be useless. This is likely to have happened many times until by chance the metal was hammered before it cooled, when partial success would have been obtained, and eventually it would have been realized that for complete command over the new metal it must be hammered while red-hot. The first iron, however, cannot have been much, if any, improvement over copper and bronze for weapons and tools, since it was less easy to work and it was not any harder than hammered copper and bronze and any cutting edge given to it by hammering would readily have become blunted. Some-

¹ W. M. Flinders Petrie, *Gerar*, pp. 14-18. In the author's opinion the higher dates are too early, because of the scanty evidence of iron in Egypt at that period, since it seems very improbable that iron should have been so plentiful just across the Egyptian border and so little used in Egypt.

how it was eventually discovered that if repeatedly heated in a charcoal fire and well hammered between the separate heatings and cooled by plunging it into water, iron would acquire a hardness superior to that of copper and bronze and it was only at this stage that it became of much practical use. This experience was gained before iron was known to the Egyptians, to whom iron smelting and iron working were probably taught by blacksmiths from Asia.

One important material employed in ancient Egypt was a vitreous glaze, which was used in small amount during the Badarian period to cover objects of stone (probably steatite), and a little later, during the predynastic period, for coating both steatite and quartz, at which period, too, objects were made of powdered quartz (heated possibly with a small proportion of natron to make the quartz cohere), and these were then glazed. It is to this glazed quartz frit that the name of Egyptian faience is given and the industry became an important one and reached a high state of development at an early date. Until the recent discoveries in northern India, it seemed probable that the invention of glaze and the making of faience had originated in Egypt, but glazed steatite and glazed quartz frit have been found at Mohenjo-Daro, which are dated from about 3000 B.C. to about 2750 B.C., and, although the Egyptian glaze and the Egyptian faience, as yet, have the priority of age by several hundred years at least, it would be premature to insist on the invention being Egyptian until the possibilities of the Indian civilization have been exhausted, which can only be done by further excavation. In any case, neither the glazing of stone, nor still less the making of such an extraordinary material as faience, are likely to have been invented in more than one place and hence, whichever of the two civilizations is the older, there must have been intercourse between them unless both derived the knowledge from some still earlier common source. If, as suggested, natron were used as a binder for the quartz powder, then the natural occurrence of natron in Egypt and its use at an early date for other purposes (for example during the Fourth Dynasty it was employed in at least one instance for preserving viscera) strengthens Egypt's claim to have invented glaze and faience. In the recent publication of

'The Royal Cemetery' at Ur by Woolley, faience is not mentioned in the Index, but in the chapter dealing with beads it is stated that 'In the Predynastic Cemetery . . . glazed frit is used, but is not common (18 cases) . . .' and that 'In the Sargonid period . . . glazed frit is not infrequent . . .' hence faience did not originate in Mesopotamia.

A very important outcome of glaze was glass, which is merely glaze used as a separate material instead of as a coating on other materials. The evolution from glaze to glass, so far as can be judged from the known evidence, took a very long time, a likely reason for this being the conservatism of the glaze worker, who like artisans of all ages and particularly of early times, would naturally have been averse to new methods and non-receptive of fresh ideas. Although glaze, while in the crucible ready for use, or even if it fell upon the floor, was glass, the worker would have been so occupied with glazing, and research being so foreign to his nature that any experiments respecting new possibilities for his material would not have occurred to him and any development would have been delayed until there happened to have been a glaze worker, with the special inquiring turn of mind that is so rare even to-day, and then some considerable time must have elapsed before the experience necessary for the manipulation of the material on the new lines could have been acquired. Although doubtless originating, as suggested, as a development of glaze, glass making would soon have branched off as a separate industry.

The early history of glass and its country of origin are obscure. One archæologist is very emphatic about Syria being the home of glass making and that the outburst of glass working in Egypt in the early Eighteenth Dynasty was due to the introduction of Syrian workmen after the Egyptian conquests in Asia.¹ But, although glass making may have been a Syrian industry before about 1500 B.C. (it certainly was much later during the Arab period when Tyre, Tripoli, Damascus and Aleppo were all noted for their glass) no proof of this can be found and no glass making centres in Syria of such an early date are known. A lump of blue glass, now in the British Museum, found in Mesopotamia 'which must be at least as early as 2200 B.C.

¹ W. M. Flinders Petrie, *Descriptive Sociology, Ancient Egyptians*, p. 187.

and is probably older ' ¹ is not part of an object and, although as it now exists it is glass, it may possibly have been made as glaze, before glass was being used for separate objects. It was found by itself and no other glass is known from the same site or of the same date. The finder says ¹ ' There is of course nothing to show that this isolated fragment of glass was made at Eridu or in Mesopotamia at all—it might be an importation from Egypt. . . . This piece of glass may merely show that the invention had reached Babylon at least as early as 2200 B.C., though it certainly was rarely used there, or we must have found examples of its use as inlay, etc. on the other sites of that period.' In the recently published description of ' The Royal Cemetery ' at Ur by Woolley, glass is not mentioned in the Index, but in the chapter on beads it is stated that there are two instances of ' glass paste,' whatever that may be, in both the predynastic cemetery and in the much later Sargonid period.

With respect to India, it is stated ² that ' no true glass has yet been found either at Harappa or Mohenjo-Daro,' though there is a material the outward resemblance of which ' to an opaque glass is very close ' and ' to the casual eye resembles an opaque glass,' but ' the granular nature of its paste proves it definitely not to be glass.'

Only fourteen examples of glass from Egypt earlier than the Eighteenth Dynasty can be traced, the dating of three of these being questioned and of the other eleven, eight are beads, one inlay, one uzat eyes and one a vase, some of the beads being of predynastic date and the vase of the Second Intermediate period. These objects must either have been made in the country or imported and, if the latter, it means that glass making was being carried on in Syria, or elsewhere, as early as predynastic times, which seems more improbable than that a few small objects (nearly 60 per cent of which are beads and bead making being the most likely beginning for glass working) should have been made in Egypt, where glass was being employed in the form of glaze from the Badarian and predynastic periods onwards. The vase of the Second Intermediate period

¹ H. R. Hall, *A Season's Work at Ur*, pp. 213-14.

² E. Mackay, in *Mohenjo-Daro and the Indus Civilization*, Sir John Marshall, pp. 576, 578, 582.

found by Brunton seems to show that the beginning of serious glass making in Egypt was earlier than is generally supposed and before the Egyptian conquests in Asia. The solution of the problem, like that of the origin of glaze, with which it is bound up, must be left to the future, but there seems no more reason why the step from glaze to glass should have been taken in Syria than in Egypt. And if there were an early flourishing glass industry in Syria, it is very remarkable that no evidence of it can be traced and also that the product was not imported into Egypt in considerable quantity. It may also be mentioned that the large use of glass inlay in the Eighteenth Dynasty for coffins, boxes, furniture and other objects appears to be typically Egyptian and was merely an extension of the much earlier use of inlay of coloured stones, rendered possible by the invention of glass made to imitate the stones previously employed, which were not available in the required quantity.

Inventions that are generally admitted to be of Egyptian origin are the use of papyrus as a writing material ; mummification and the mural painting in tombs and temples.

Although Egypt is somewhat isolated geographically and was still more isolated anciently, on account of the very considerable difficulties of communication that then existed, and although it was largely self-contained and needed no outside help for the necessities and little for the luxuries of life, yet it was not cut off absolutely from the rest of the world, and two important examples of the result of intercourse between Egypt and its neighbours, namely bronze and iron, have already been mentioned. But, in addition to these, other foreign articles found their way into Egypt, though, until a late period, such imports were few in number, the greater proportion of the materials used being of local origin. Thus the building materials, brick, stone, mortar and plaster, were all local ; glaze, glass and pottery (wherever they may have originated) were all made in the country from native materials ; the metals gold and silver and their alloy electrum, as also the ores of copper and lead from which these two latter metals were produced all occurred in the country ; the animal fats and beeswax were native products ; the pigments were almost entirely naturally occurring materials, or were made from such materials ; the precious

and semi-precious stones employed, with two exceptions (jade, of which only about two examples are known, and lapis lazuli) were of local origin, as were also the ornamental and monumental stones (except yellow jasper and obsidian); the textile fabrics were woven in Egypt and baskets, ropes and mats were made from fibres that grew in the country; the skins made into leather were local and most of the dyes with which the textile fabrics and the leather were coloured were probably Egyptian; and the foodstuffs (chiefly cereals, green vegetables, oil,¹ fruit, honey, meat and fish) were all produced in the country.

The principal materials imported into Egypt may now be considered, but especially those received up to the early part of the Eighteenth Dynasty, about which period began a much greater intercourse between Egypt and other nations, largely as a result of the Egyptian conquests in Asia, the natural effect of which was a considerable increase in the import of commodities from abroad, which included a number of articles received as tribute or taken as the spoils of war.

The imports were almost entirely either from western Asia, or from Nubia and the Sudan, and to what extent materials were ordinarily received from the countries to the west of Egypt is not known, though this was certainly not an important source of supply.

The principal materials received from Asia before the beginning of the Eighteenth Dynasty, taking them in alphabetical order, were bronze, and possibly also tin for making bronze, from the Middle Kingdom onwards; emery, of which only a few objects are known, during the predynastic and early dynastic periods; lapis lazuli, continuously in small amount from predynastic times; obsidian, the total amount of which was not great, from predynastic times; oil, probably chiefly olive oil, from the early dynastic period onwards; resins and wood continuously from the predynastic period.

From about the middle of the Eighteenth Dynasty a number of new materials began to be imported into Egypt from Asia, the principal of which were copper, which up to about this date had probably been produced largely from local ores; iron in the form of a few small objects with probably also a very

¹ A small amount of oil for special purposes was imported.

small amount of metal, the amount gradually increasing until iron began to be smelted in the country ; yellow jasper, occasionally during the Eighteenth Dynasty ; orpiment during the Empire as also varnish or varnish resins, the import of which latter continued until about the Twenty-sixth Dynasty, when it practically ceased.

The materials received from, or through, Nubia and the Sudan were chiefly ebony, gold, ivory, fragrant gum-resins and fragrant woods. It is worthy of note that, so far as is known, there was not any material used in ancient Egypt until about the Eighteenth Dynasty that can be traced to India, though India and Ceylon possessed, among other commodities, precious and semi-precious stones and odoriferous resins and woods, materials that were in great demand in Egypt and that are of small bulk and easily transported. It is possible, however, that some of the fragrant woods mentioned in the records as having been received from Punt may have been of Indian origin. From the Eighteenth Dynasty onwards the varnish resins may have come from, or through, India and possibly at a later date indigo and, still later, almost certainly cotton.

To bring to Egypt most of the foreign materials enumerated Egyptian ships were trading both in the Mediterranean and the Red Sea, the former sailing along the coasts of Palestine and Syria to the port of Byblos, especially to carry the bulky timber from the Lebanons that could not easily be transported otherwise, and the latter down the Gulf of Suez and the Red Sea to the Somali and Arabian coasts ; the Sudan and Nubian produce was carried by way of the Nile.

At a very early date the whole country, and particularly the desert, was scoured for useful natural materials, thus during the Old Kingdom, when the capital was at Memphis in the Delta, alabaster was quarried near Helwan ; amethyst was brought either from the eastern or western desert ; a special diorite was brought from the western desert in Nubia ; gold from Nubia ; granite from Aswan ; malachite and copper from Sinai ; natron from the Wâdi Natrûn ; porphyritic rocks from the eastern desert ; schist from between Qena and Quseir and turquoise from Sinai.

Intercourse with other countries meant, not only the import

of foreign commodities, but also the export of Egyptian commodities to pay for them, since at the time under consideration, coined money was unknown and barter was the only means of exchange. Exactly what these exports were is not known, but among the objects the Egyptians had to offer were faience glass, gold, jewellery, including precious and semi-precious stones, linen, papyrus and stone vessels.

But more valuable than the material objects exchanged was the knowledge given and received, a subject already touched upon, but any detailed discussion of which is outside the scope of the present book.

APPENDIX

CHEMICAL ANALYSES

MODERN EGYPTIAN GYPSUM ¹

	%	%	%
Gypsum (hydrated calcium sulphate) . . .	75.4	85.2	89.9
Sand	7.6	3.7	2.1
Calcium carbonate	15.2	9.4	7.5
Oxides of iron and aluminium	1.0	1.0	0.5
	99.2	99.3	100.0

ANCIENT EGYPTIAN LIME MORTAR (ROMAN PERIOD) ²

	%	%	%	%
Sand	73.5	22.3	54.9	29.1
Oxides of iron and aluminium	3.7	7.5	13.3	4.0
Lime	10.1	33.9	14.6	34.7
Magnesia	0.7	1.8	3.2	2.1
Sulphur trioxide	1.4	3.2	nil	0.9
Carbon dioxide, combined water, etc.	10.6	31.3	14.0	29.2
	100.0	100.0	100.0	100.0

¹ From Helwan. Analyses by the author.

² Analyses by the author.

ANCIENT EGYPTIAN GYPSUM MORTAR ¹

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Gypsum (hydrated calcium sulphate) . . .	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Sand	46.9	66.9	73.1	78.0	47.3	54.0	23.4	57.2	54.4	54.4	89.2	70.7	79.6	80.0	97.3	84.0	89.2	78.6	99.5
Calcium carbonate . . .	12.6	25.5	15.4	12.3	11.5	11.4	4.8	7.4	3.2	7.8	2.0	9.5	6.9	12.8	2.0	8.0	6.0	13.5	tr.
Magnesium carbonate . .	37.1	tr.	6.9	4.3	38.6	32.3	58.0	30.4	39.5	26.6	tr.	8.0	3.5	tr.	—	—	4.8	3.7	—
Oxides of iron and aluminium	1.3	0.8	1.6	2.1	tr.	1.3	3.8	3.8	tr.	tr.	tr.	1.3	tr.	tr.	—	—	—	0.8	—
Not determined	1.5	2.0	1.8	1.4	1.3	1.0	0.7	1.1	0.6	2.2	0.8	2.6	1.1	1.2	—	tr.	tr.	2.9	—
	0.6	4.8	1.2	1.9	1.3	—	9.3	0.1	2.3	9.0	8.0	7.9	8.9	6.0	0.7	—	—	0.5	0.5
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Nos. 1 to 6. From the sphinx.

Nos. 7 to 9. From the valley temple of Chephren.

Nos. 10 and 11. From the pyramid of Chephren.

Nos. 12 to 15. From the pyramid of Cheops.

Nos. 16 and 17. From the Mastaba el-Faraḥn.

No. 18. From the hypostyle hall, Karnak.

No. 19. From the tomb of Hefephres.

IVth Dynasty.

¹ Analyses by the author.ANCIENT EGYPTIAN GYPSUM PLASTER ¹

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Gypsum (hydrated calcium sulphate) . . .	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Sand	78.2	76.7	78.1	75.9	83.0	78.1	74.4	84.8	66.3	17.0	75.9	68.5	67.1	36.9	15.5	39.8	40.5	42.7	45.0	83.3	34.6
Calcium carbonate* . . .	10.8	13.0	11.0	11.0	17.0	15.0	15.0	9.0	16.0	10.0	14.0	12.0	11.0	27.0	17.0	15.0	30.0	25.0	36.0	14.0	27.0
	11.0	10.3	10.9	13.1	tr.	6.9	10.6	6.2	17.7	73.0	10.1	19.5	21.9	36.1	67.5	45.2	29.5	32.3	19.0	2.7	38.4
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Nos. 1 to 10. From the tomb of Tut-ankhamūn. See A. Lucas, *Appendix II*, pp. 162-3 in *The Tomb of Tut-ankh-Amen*, II, Howard Carter. Some of these specimens are of a grey colour owing to the presence of particles of unburnt fuel.

No. 11. Used as a cement to repair the lid of the sarcophagus in the tomb of Tut-ankhamūn. This was the principal cementing material though there was also another cement in places consisting of a mixture of resin and powdered limestone. See A. Lucas, *op. cit.*, p. 168.

Nos. 12 and 13. From the "Cache of Akhenaten" (XVIIIth Dynasty). No. 14. From the tomb of Siptah (XIXth Dynasty).

No. 15. From the tomb of Setnakht (No. 14, XXth Dynasty). Nos. 16 to 19. From the tomb of Seti II (No. 15, XIXth Dynasty).

Nos. 20 and 21. From the tomb of Ramesses XIIIth (XXth Dynasty).

¹ Analyses by the author.

* With a small proportion of oxides of iron and aluminium.

ANCIENT EGYPTIAN WHITEWASH¹

	1	2
	%	%
Gypsum (hydrated calcium sulphate)	1.5	9.6
Sand	11.0	32.0
Calcium carbonate, etc.	87.5	58.4
	100.0	100.0

No. 1. From the 'Cache of Akhenaten' (XVIIIth Dynasty).

No. 2. From the tomb of Seti II (No. 15, XIXth Dynasty).

¹ Analyses by the author.

PLASTER MOULDS FOR BRONZE FIGURES²

	1	2
	%	%
Gypsum (hydrated calcium sulphate)	97.3	95.8
Silica	1.3	3.4
Calcium carbonate	tr.	tr.
Oxides of iron and aluminium	1.4	0.8
	100.0	100.0

² Analyses by the author. See C. C. Edgar, *Greek Moulds*, Cairo Cat. p. iii.

ANCIENT EGYPTIAN FAIENCE

Body Material

	1	2	3	4	5
	%	%	%	%	%
Silica	94.00	94.18	94.18	99.6	94.7
Alumina	1.80	0.59	1.93	} 0.3	1.4
Oxide of iron	0.89	1.64	0.28		
Lime	2.00	1.73	1.60	0.3	1.7
Magnesia	1.05	1.82	0.05	—	1.8
Alkalis	0.25	—	1.11	—	0.4
Loss on ignition	0.11	0.04	1.00	—	—
	100.10	100.0	100.15	100.2	100.0

Nos. 1, 2, 3. W. Burton, *Ancient Egyptian Ceramics*, in *Journal Royal Society of Arts*, LX (1912), p. 594.

No. 4. XIXth Dynasty. Analysis by the author. Specimen of finely divided, white material.

No. 5. XIXth-XXth Dynasty. Analysis by the author. Specimen of coarse, yellowish-brown material.

Glaze

	1	2	3
	%	%	%
Silica	75.6	47.5	74.0
Alumina	0.8	1.0	1.5
Oxide of iron	0.8	2.1	2.6
Lime	3.8	6.1	2.4
Magnesia	0.7	0.7	0.8
Oxide of tin	nil	4.8	0.3
Oxide of lead	nil	31.4	1.4
Oxide of copper	1.8	nil	nil
Potash	10.7	tr.	2.7
Soda	5.6	6.2	14.1
Oxide of manganese	0.3	0.2	0.2
	100.1	100.0	100.0

No. 1. Blue colour: Roman date from Dîma (Fayûm). Analysis by J. Clifford.

No. 2. Colour not stated: Arab date from Fostat. Analysis by J. Clifford: is a lead glaze.

No. 3. Colour not stated: Arab date from Fostat. Analysis by J. Clifford: is a salt glaze.

ANCIENT EGYPTIAN GLASS¹

Silica	% 68.3	% 68.0	% 59.0	% 60.7	% 59.8	% 59.9	% 60.3	% 60.1	% 58.7	% 57.9	% 58.0	% 60.4	% 60.1
Oxides of iron and alu- minium	3.2	4.0	3.9	2.3	2.7	2.7	2.3	3.1	5.0	5.3	5.0	3.5	3.8
Lime	4.9	5.0	3.7	3.6	3.4	3.9	3.8	3.7	3.8	5.4	5.6	3.8	5.1
Magnesia	1.0	0.9	3.0	3.0	3.0	2.8	2.6	2.0	1.8	1.1	1.0	2.2	1.0
Potash	2.0	2.2	30.2	29.8	30.5	30.1	30.4	1.4	29.6	29.7	29.9	1.4	28.7
Soda	20.2	19.4		0.6	0.5	0.7	0.6	29.1		0.4	0.4	28.3	
Oxide of manganese .	0.3	0.3	—	tr.	tr.	tr.	tr.	tr.	tr.	nil	tr.	—	1.1
Oxide of cobalt . . .	—	—	—	—	—	—	—	—	—	tr.	—	tr.	—
Oxide of copper . . .	—	—	—	—	—	—	—	—	—	tr.	—	tr.	tr.
	99.9	99.8	100.2	100.0	99.9	100.1	100.0	99.8	99.9	99.8	99.9	100.0	99.8
Trans. XIIth		Yell. XIIth	Or.-yell. XVIIIth	Blue XVIIIth	Blue XVIIIth	Blue XVIIIth	Blue XVIIIth	Blue XXth	Blue XXth	Blue Persian	Blue Persian	Green XXth	? Byzant.

¹ H. D. Parodi, *La Verrerie en Egypte*, 1908.

ANCIENT ARAB GLASS¹

Silica	% 67.8	% 68.0	% 66.4	% 67.0	% 55.7	% 56.6	% 68.7	% 66.7	% 68.3	% 67.4	% 68.3	% 67.9	% 68.0	% 68.0	% 63.1	% 64.2	% 58.1
Oxides of iron and aluminium . .	4.0	4.2	5.1	5.0	8.3	8.0	2.2	5.4	3.3	2.7	2.1	2.9	2.6	2.1	0.6	3.0	7.4
Lime	2.9	2.6	4.7	4.2	4.6	4.7	8.6	7.4	8.7	8.1	8.0	8.3	8.1	8.2	3.5	5.0	4.9
Magnesia . . .	0.9	0.9	1.4	1.1	3.3	3.7	4.2	3.5	3.2	4.0	3.7	3.7	4.1	4.2	—	nil	3.0
Potash	23.5	23.4	22.6	21.7	25.1	24.0	2.9	3.9	2.5	2.6	2.5	2.5	2.1	2.7	31.0		25.3
Soda	0.9	0.8	0.6	0.9	1.9	1.3	0.7	0.7	0.6	0.7	0.8	0.8	0.7	0.8	0.8	0.8	1.1
Oxide of manganese	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Oxide of cobalt .	tr.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Oxide of copper .	—	—	—	—	1.0	1.1	—	—	—	—	—	—	—	—	—	—	—
Oxide of sulphur .	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	100.0	99.9	100.8	99.9	99.9	99.4	99.8	100.0	99.3	99.9	100.1	99.4	99.7	100.0	99.0	99.7	99.8
Blue	Blue	—	—	—	Blue	Blue	—	—	—	—	—	—	—	—	—	—	—

¹ H. D. Parodi, *La Verrerie en Egypte*, 1908.

ANCIENT EGYPTIAN GLASS ¹

	1	2	9	13	21	23	24	3	4	5	14	6	15	16	7	8	18	19	20	10	11	22	12	17		
Silica	%	61.7	59.6	62.6	68.1	66.3	67.5	%	62.7	62.4	%	64.1	%	64.7	%	62.3	%	59.1	%	55.6	%	63.2	%	65.9		
Oxide of iron . . .	%	0.7	0.4	0.6	0.7	0.8	0.9	%	1.1	0.8	%	0.5	%	0.8	%	0.6	%	0.9	%	1.3	%	0.5	%	0.8		
Oxide of alu- minium	%	2.5	3.0	0.8	1.9	3.3	3.9	%	2.9	1.5	%	1.3	%	2.8	%	0.8	%	3.6	%	3.5	%	1.0	%	2.5		
Lime	%	10.1	10.6	9.3	4.2	7.1	9.9	%	10.3	9.2	%	7.0	%	7.1	%	8.4	%	10.7	%	8.4	%	9.1	%	9.1		
Magnesia	%	5.1	4.4	4.4	1.3	1.5	1.2	%	4.5	3.1	%	3.8	%	2.1	%	4.2	%	3.1	%	2.7	%	3.2	%	3.7		
Potash	%	1.6	7.4	2.8	1.9	0.4	0.2	%	19.0	2.8	%	2.8	%	0.5	%	1.9	%	7.6	%	0.8	%	0.4	%	1.9		
Soda	%	17.6	14.9	18.2	18.9	19.3	14.8	%	20.3	18.1	%	19.3	%	20.4	%	19.9	%	10.3	%	12.2	%	20.6	%	18.0		
Oxide of man- ganese	%	0.5	tr.	—	—	0.6	0.8	%	—	—	%	0.3	%	0.5	%	0.9	%	0.7	%	0.3	%	tr.	%	—		
Oxide of copper . .	%	0.3	0.5	0.5	2.7	1.0	0.3	%	—	2.0	%	0.2	%	0.2	%	12.0	%	2.1	%	4.4	%	—	%	—		
Oxide of lead . . .	%	—	—	—	—	—	—	%	—	0.5	%	—	%	1.3	%	—	%	3.0	%	6.3	%	—	%	—		
Oxide of tin	%	—	—	0.5	—	—	—	%	—	—	%	—	%	—	%	—	%	—	%	—	%	—	%	0.5		
Sulphur trioxide . .	%	—	—	0.5	—	—	—	%	2.4	0.7	%	0.8	%	—	%	1.2	%	0.5	%	1.8	%	1.1	%	—		
	100.1	100.8	100.2	99.7	100.3	100.2	100.0	91.1	100.1	100.6	99.5	100.1	99.9	100.2	100.0	100.6	100.4	100.6	99.3	100.9	100.0	100.5	100.2	100.0		
	Blue												Black			Purple			Red			Colourless			Honey Milk White	

Nos. 1 to 12 inclusive are from the XVIIIth Dynasty : Nos. 13 to 22 inclusive are of the period 2nd to 1st century B.C.; and Nos. 23 and 24 are Alexandrine.
¹B. Neumann and G. Kotyga, Antike Gläser, ihre Zusammensetzung und Färbung, in Zeitschrift für angewandte Chemie, 1923, pp. 776-80; 837-64.
The numbers are those of Neumann and Kotyga: the Färbung specimens have been rearranged according to colour.

ARAB GLASS FROM FOSTAT¹

	%	%	%	%
Silica	71.2	70.5	66.3	49.4
Phosphoric anhydride.	0.3	0.6	0.6	1.2
Oxide of iron	1.4	1.9	} 4.6	8.6
Oxide of aluminium	1.0	0.8		14.5
Lime	8.1	7.8	10.5	18.7
Magnesia	3.2	1.2	1.0	1.4
Potash	2.1	tr.	3.8	3.5
Soda	11.4	16.1	11.1	2.4
Oxide of manganese	1.2	1.1	2.4	0.3
	99.9	100.0	100.3	100.0
	Blue	Green	Green	Green

¹ Analyses by J. Clifford.

MODERN EGYPTIAN COPPER ORE

	1 %	2 %	3 %
Copper	3.1	36.3	48.6
Iron	25.8	—	—
Oxide of aluminium	2.4	—	—
Insoluble residue	55.4	—	—
Sulphuric acid	tr.	—	—
Nickel and zinc	nil	—	—
Lead	—	—	—
Sulphur	—	—	—
Not determined	13.3	63.7	51.4
	100.0	100.0	100.0

No. 1. Chryocolla. From Wâdî Samra (Eastern Sinai). Analysis by C. H. Desch. Kindly communicated by G. A. Garfitt, Honorary Secretary, Sumerian Copper Committee.

Nos. 2 and 3. From Wâdî Araba (eastern desert). Analyses by Chemical Department, Cairo.

ANCIENT EGYPTIAN COPPER SLAG ¹

	%
Insoluble in acid	37.9
Copper	21.7
Lead ²	38.0
Iron	1.9
Nickel and cobalt	tr.
Arsenic	0.5
Antimony, silver, bismuth	nil
	100.0

¹ From near Serâbât el-Khâdim in Sinai. Analysis by J. Sebelien, *Early Copper and its Alloys*, in *Ancient Egypt*, 1924, p. 10.

² The presence of such a large proportion of lead is very extraordinary and needs explanation.

ANCIENT EGYPTIAN COPPER OBJECTS ¹(a) Nine specimens.²

Impurities : arsenic ; other metals absent.

Arsenic : present, 4 (1 strong ; 3 traces) ; absent, 5.

(b) Five specimens.³

Impurities : tin ; arsenic and antimony ; other metals absent.

Tin : present, 4 (1 strong ; 3 traces) ; absent, 1.

Arsenic : present, 4 (3 traces) ; absent, 1.

Antimony : present, 1 (trace) ; absent, 4.

(c) Five specimens.⁴

Impurities : tin and arsenic.

Tin : present, 1 (1 per cent) ; absent, 4.

Arsenic : present, 2 (1 trace) ; absent, 3.

¹ Analyses by M. Berthelot.

² J. de Morgan, *Recherches sur les origines de l'Égypte*, II, pp. 247-53.

³ J. de Morgan, *op. cit.*, I, pp. 223-9. Whether any, or all, of (b) are included in (a) is not clear.

⁴ M. Berthelot, *Étude sur les métaux*, in *Fouilles à Dabchour, mars-juin, 1894*. J. de Morgan, pp. 136-45.

ANCIENT EGYPTIAN COPPER OBJECTS¹

No.	Object	Copper	Iron	Zinc	Arsenic	Tin	Silver; Bismuth	Nickel	Lead	Sulphur	Sand	Not determined	Total
		%	%	%	%	%	%	%	%	%	%	%	%
1	Axe	98.0	—	—	—	—	—	—	—	—	—	2.0	100.0
2	Axe	98.1	—	0.3	tr.	—	—	—	—	—	—	1.6	100.0
3	Axe	100.0	tr.	—	—	—	—	—	—	—	—	—	100.0
4	Axe	99.6	—	—	—	—	—	—	—	—	—	0.4	100.0
5	Axe	97.2	—	0.3	—	—	—	tr.	—	—	—	2.5	100.0
6	Axe	99.0	—	—	—	—	tr.	—	—	—	—	1.0	100.0
7	Axe	98.3	—	—	—	—	—	—	—	—	—	1.7	100.0
8	Adze	99.9	tr.	tr.	—	—	tr.	—	—	—	—	0.1	100.0
9	Adze	97.6	—	—	—	—	—	—	—	—	—	2.4	100.0
10	Adze	97.7	tr.	—	—	—	—	—	—	—	—	2.3	100.0
11	Adze	99.6	—	—	—	—	tr.	—	—	—	—	0.4	100.0
12	Adze	97.0	0.5	—	—	—	—	0.4	—	0.3	—	1.8	100.0
13	Adze	94.2	2.5	—	—	—	—	—	—	—	0.4	2.9	100.0
14	Chisel	98.7	—	—	—	—	tr.	—	—	—	—	1.3	100.0
15	Chisel	98.0	tr.	tr.	0.3	—	tr.	—	—	—	—	1.7	100.0
16	Chisel	98.8	0.6	0.2	—	—	tr.	—	—	—	—	0.4	100.0
17	Knife	98.5	—	0.3	0.6	—	—	—	—	—	—	0.6	100.0
18	Bar	98.1	—	—	0.2	—	—	—	—	—	—	1.7	100.0
19	Bar	88.0	0.1	—	—	—	—	—	—	—	8.0	3.9	100.0
20	Chisel	97.7	0.5	tr.	—	—	—	—	—	—	—	1.8	100.0
21	Adze	98.0	tr.	tr.	tr.	—	—	—	tr.	—	—	2.0	100.0
22	Chisel	97.6	1.2	—	—	—	—	—	—	—	1.4	—	100.2
23	Chisel	98.5	tr.	—	—	—	—	—	—	—	0.3	1.2	100.0
24	Adze	58.0	—	—	—	—	—	—	—	—	20.0	22.0	100.0

Nos. 1 to 19 inclusive, Ist Dynasty.

No. 20, IInd Dynasty.

No. 21, VIth Dynasty.

No. 22, XIIth Dynasty.

No. 23, XVIIIth Dynasty.

No. 24, possibly XXth Dynasty.

¹ Analyses by J. Sebelien, *Early Copper and its Alloys*, in *Ancient Egypt*, 1924, p. 8.

ANCIENT EGYPTIAN COPPER OBJECTS

No.	Object	Copper	Iron	Tin	Lead	Nickel Cobalt	Arsenic	Antimony	Bismuth	Sulphur	Manganese	Not determined	Total
		%	%	%	%	%	%	%	%	%	%	%	%
1	Axe	97·4	0·2	tr.	0·2	1·3	0·5	tr.	—	—	0·1	0·3	100·0
2	Dagger	99·5	0·1	nil	tr.	nil	0·4	—	nil	—	—	—	100·0
3	Model Knife	99·6	0·2	0·2	—	—	—	—	—	—	—	—	100·0
4	Chisel	93·2	tr.	tr.	0·1	—	0·1	—	—	—	—	—	100·0
5	Adze	99·6	tr.	nil	—	—	0·4	tr.	—	tr.	—	—	100·0
6	Adze	99·5	tr.	nil	—	—	0·5	tr.	—	tr.	—	—	100·0
7	Pick	100·0	—	tr.	—	—	pres.	tr.	—	—	—	—	100·0
8	Statue	98·2	0·7	—	—	1·1	—	—	—	tr.	—	—	100·0
9	Model Tool	98·4	0·2	nil	tr.	—	0·3	tr.	tr.	—	—	1·1	100·0
10	Axe	93·3	0·2	0·5	—	—	3·9	0·2	—	—	—	1·9	100·0
11	Strip	95·0	0·3	tr.	0·3	0·1	4·2	—	tr.	—	—	0·1	100·0
12	Axe	88·9	—	0·2	0·6	—	5·6	0·7	—	—	—	4·0	100·0
13	Ingot	93·0	5·9	—	—	—	0·1	—	—	1·0	—	—	100·0
14	Axe	96·9	0·7	0·2	—	tr.	1·5	—	—	tr.	—	0·7	100·0
15	Knife	96·7	1·2	tr.	0·6	0·3	0·8	—	0·4	—	—	—	100·0
16	Knife	97·1	0·4	0·2	—	—	2·3	—	—	—	—	—	100·0

No. 1. Middle Predynastic. Sir H. C. H. Carpenter, *Nature*, 130 (1932), pp. 625-6.

No. 2. Ist Dynasty. H. Garland and C. O. Bannister, *Ancient Egyptian Metallurgy*, p. 34.

No. 3. IIIrd Dynasty. Analysis by A. Lucas, in *Excavations at Saqqara* (1911-12). *The Tomb of Hesy*, J. E. Quibell, p. 40.

No. 4. Early Dynastic (Nubia). Analysis by C. O. Bannister, in *Report of the British Assn.*, C. H. Desch, 1928, pp. 437-41. Also silver, 2·5 per cent and gold 4·1 per cent.

No. 5, 6, 7. IVth Dynasty. J. H. Gladstone, *Proc. Soc. Bibl. Arch.* xiv (1892), pp. 223-7.

No. 8. Pepy I statue, VIth Dynasty. C. H. Desch, *Report of the Brit. Assn.*, 1928, pp. 437-41.

No. 9. Old Kingdom. Analysis by J. H. Gladstone, in *El Kab*, J. E. Quibell, p. 4.

No. 10. XIIth Dynasty. J. H. Gladstone, *Proc. Bibl. Arch.* xii (1890), pp. 227-34.

No. 11. XIIth Dynasty. H. Garland and C. O. Bannister, *op. cit.*, p. 68.

No. 12. Possibly XIIth Dynasty. G. B. Phillips, in *Ancient Egypt*, 1924, p. 89.

No. 13. Possibly XIIth Dynasty. From Bir Nasb, Sinai, C. H. Desch, *op. cit.*, pp. 437-41.

- No. 14. Pan Grave. Sir H. C. H. Carpenter, *Nature*, 127 (1931), pp. 589-91.
 No. 15. XVIIIth Dynasty. Analysis by W. B. Pollard, in *Journ. Inst. Metals*, H. Garland, x (1913), p. 330.
 No. 16. XIXth Dynasty. Analysis by Dr. Percy, in *Proc. Bibl. Arch.*, J. H. Gladstone, xii (1890), p. 229.

ANCIENT EGYPTIAN BRONZE OBJECTS

No.	Object	Copper	Tin	Lead	Antimony	Arsenic	Nickel	Iron	Zinc	Sulphur	Not determined	Total
		%	%	%	%	%	%	%	%	%	%	%
1	Rod	89.8	9.1	—	tr.	0.5	—	tr.	—	tr.	0.6	100.0
2	Vase	86.2	5.7	nil	—	nil	—	nil	nil	—	8.1	100.0
3	Bowl	85.8	3.5	8.5	—	—	—	0.2	—	—	2.0	100.0
4	Axe	85.9	12.1	0.8	—	—	—	—	—	—	1.2	100.0
5	Chisel	93.6	7.4	—	tr.	0.5	—	—	—	—	—	101.5
6	Bracelet	68.4	16.3	nil	—	nil	—	tr.	tr.	—	15.3	100.0
7	Hook	69.2	9.8	—	—	nil	—	—	—	—	21.0	100.0
8	Chisel	96.4	2.2	—	—	0.4	—	—	—	—	1.0	100.0
9	Figurine	91.9	6.3	—	—	—	—	—	—	—	1.8	100.0
10	Figurine	88.4	11.9	—	—	—	—	—	—	—	—	100.3
11	Adze	89.8	3.1	—	tr.	0.3	—	—	0.4	—	6.4	100.0
12	Chisel	88.0	12.0	0.1	tr.	0.4	—	—	0.3	—	—	100.8
13	Axe	89.6	6.7	—	tr.	1.0	—	0.5	—	—	2.2	100.0
14	Axe	90.1	7.3	—	tr.	0.2	—	—	—	tr.	2.4	100.0
15	Adze	67.6	9.6	—	—	—	0.6	tr.	—	—	22.2	100.0

- No. 1. IVth Dynasty. J. H. Gladstone, *Proc. Soc. Bibl. Arch.* xiv (1892), pp. 223-7.
 No. 2. VIth Dynasty. M. Berthelot, in *Fouilles à Dahchour*, 1894, J. de Morgan, pp. 136-45.
 No. 3. Possibly XIth Dynasty. G. B. Phillips, in *Ancient Egypt*, 1924, p. 89.
 Nos. 4, 5. XIIth Dynasty. J. Sebelien, *Ancient Egypt*, 1924, p. 8.
 Nos. 6, 7. XIIth Dynasty. M. Berthelot, *op. cit.*, pp. 136-45.
 No. 8. XIIth Dynasty. J. H. Gladstone, *Proc. Soc. Bibl. Arch.*, xii (1890), pp. 227-34.
 No. 9. IXth or XIth Dynasty. H. R. Hall, *Some Early Copper and Bronze Egyptian Figurines*, in *Annals of Arch. and Anthropol.*, Liverpool, xvi (1929), pp. 14, 15.
 No. 10. XIth or XIIth Dynasty. H. R. Hall, *op. cit.*
 Nos. 11, 12. XVIIIth Dynasty. J. Sebelien, *op. cit.*, p. 8.
 Nos. 13, 14. XVIIIth Dynasty. J. H. Gladstone, *Proc. Soc. Bibl. Arch.*, xii (1890), pp. 227-34.
 No. 15. XIXth Dynasty. J. Sebelien, *op. cit.*, p. 8.

ANCIENT EGYPTIAN GOLD OBJECTS

	1	2	3	4	5	6	7	8	9
	%	%	%	%	%	%	%	%	%
Gold . . .	79.7	84.2	84.0	78.0	81.7	80.8	92.3	92.2	90.5
Silver . . .	13.4	13.5	13.0	18.0	16.1	14.7	3.2	3.9	4.5
Copper . . .	nil	nil	nil	—	trace	4.1	nil	nil	nil
Not determined	6.9	2.3	3.0	4.0	2.2	0.4 ¹	4.5	3.9	5.0
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	10	11	12	13	14	15	16	17	18
	%	%	%	%	%	%	%	%	%
Gold . . .	92.7	90.0	82.9	85.9	96.4	82.3	72.1	89.5	99.8
Silver . . .	4.9	—	16.6	13.8	1.9	14.3	17.2	11.2	—
Copper . . .	—	—	0.5	0.3	pres.	1.5	13.1	nil	—
Not determined	2.4	10.0	—	—	1.7	1.9	—	—	0.2
	100.0	100.0	100.0	100.0	100.0	100.0	102.4	100.7	100.0

Nos. 1, 2, 3. 1st Dynasty. Analyses by J. H. Gladstone, in *The Royal Tombs of the Earliest Dynasties*, W. M. Flinders Petrie, II, p. 40.

Nos. 4, 5. VIth Dynasty. Analyses by J. H. Gladstone, in *Denderah*, W. M. Flinders Petrie, pp. 61-2.

No. 6. VII-VIIIth Dynasty. Part of bracelet from Matmar. Analysis by Sir H. C. Carpenter. Kindly communicated by the finder, Mr. Guy Brunton.

Nos. 7, 8. XIth Dynasty, Nos. 9, 10, 11: XIIth Dynasty, No. 18, Persian period. Analyses by M. Berthelot, *Sur l'or égyptien*, in *Annales du Service*, II (1901), pp. 157-63.

Nos. 12, 13. XIIth Dynasty. Analyses by M. Berthelot, *Étude sur les métaux in Fouilles à Dahchour*, J. de Morgan, pp. 145-6.

Nos. 14, 15, 16, 17. XVIIIth Dynasty. Analyses by W. B. Pollard, in *The Tomb of Yuua and Thuiu*, J. E. Quibell, *Cairo Cat.*, pp. 78-9.

¹ Is iron.

ANCIENT EGYPTIAN ELECTRUM OBJECTS

	1	2	3	4	5	6	7
	%	%	%	%	%	%	%
Gold.	80.1	78.7	77.3	78.2	72.9	67.0	71.0
Silver	20.3	20.9	22.3	21.1	20.5	25.0	29.0
Copper	—	—	—	—	pres.	8.0	—
Not determined .	—	0.4	0.4	0.7	6.6	—	—
	100.4	100.0	100.0	100.0	100.0	100.0	100.0

Nos. 1, 2, 3, 4. XI–XIIth Dynasty. Analyses by M. Berthelot, *Sur l'or égyptien in Annales du Service*, II (1901), pp. 157–63.

No. 5. XVIIIth Dynasty. Analysis by W. B. Pollard, in *The Tomb of Yuaa and Thuiu*. J. E. Quibell, *Cairo Cat.*, pp. 78–9.

No. 6. XVIIIth Dynasty. Analysis by Alex. Scott in *The Tomb of Tut-ankh-Amen*, Howard Carter, II, p. 211.

No. 7. XVIII–XIXth Dynasty. C. R. Williams, *Gold and Silver Jewellery and Related Objects*, p. 118.

ANCIENT EGYPTIAN SILVER OBJECTS

	1	2	3	4	5	6
	%	%	%	%	%	%
Gold.	38.1	8.9	14.9	pres.	8.7	8.4
Silver	60.4	90.1	74.5	69.2	82.5	84.9
Copper	1.5	1.0	—	pres.	8.9	4.3
Lead	—	nil	—	nil	—	—
Not determined .	—	—	10.6	30.8	—	2.4
	100.0	100.0	100.0	100.0	100.1	100.0

	7	8	9	10	11
	%	%	%	%	%
Gold	5.1	2.7	3.2	17.9	1.2
Silver	90.2	92.1	92.5	82.1	94.8
Copper	4.5	3.3	3.9	tr.	1.7
Lead	0.2	tr.	0.5	—	0.2
Not determined	—	1.9	—	—	2.1
	100.0	100.0	100.0	100.0	100.0

No. 1. Early Dynastic. Analysis by C. Friedal, in *Les nouvelles fouilles d'Abydos*, 1895–1896, E. Amélineau, p. 274.

- No. 2. IIIrd Dynasty. Analysis by H. E. Cox. From the tomb of Heteres at Giza, discovered by G. A. Reinser.
- No. 3. XI-XIIth Dynasty. Analysis by M. Berthelot, in *Annales du Service* II (1901), pp. 157-63.
- No. 4. XIIth Dynasty. Analysis by M. Berthelot, in *Fouilles à Dahchour*, J. de Morgan, pp. 145-6.
- Nos. 5, 6. XVIIIth Dynasty. Analyses by W. B. Pollard, in *The Tomb of Yuaa and Thuiu*, J. E. Quibell, pp. 78-9.
- No. 7. XVIIIth Dynasty. Analysis by Alex. Scott, in *The Tomb of Tut-ankh-Amen*, Howard Carter, p. 210.
- No. 8. XVIIIth Dynasty. Analysis by H. E. Cox. Found by Pendlebury at El-Amârna. H. Frankfort and J. D. S. Pendlebury, *The City of Akhenaten*, II, p. 60.
- No. 9. XIXth Dynasty. C. R. Williams, *Gold and Silver Jewellery and Related Objects*, p. 29.
- No. 10. 4th-5th century B.C. C. R. Williams, *op. cit.*, p. 143.
- No. 11. Early A.D. Analysis by H. E. Cox. Found by W. B. Emery at Kostol in Nubia.

MODERN NATRON FROM THE WADI NATRŪN¹

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Sodium carbonate ²	38.2	22.4	28.9	35.5	43.5	28.9	58.6	75.0	67.8	33.4	38.3	41.8	35.4	53.9
Sodium bicarbonate ²	32.4	6.2	20.5	25.8	33.8	9.9	14.3	5.0	8.6	25.2	18.3	29.4	12.1	24.2
Sodium chloride	6.7	26.4	24.8	14.0	4.8	26.8	7.4	9.4	4.3	20.8	2.2	11.9	12.4	1.9
Sodium sulphate	2.3	39.3	5.8	3.0	3.3	27.4	1.3	1.2	0.8	6.1	tr.	3.4	29.9	tr.
Water, free and combined	16.5	5.6	12.8	13.1	13.1	6.9	4.3	3.7	1.9	11.6	10.1	11.2	10.2	20.0
Matter insoluble in water	3.9	0.1	7.2	8.6	1.5	0.1	14.1	5.7	16.6	2.9	31.1	2.3	tr.	tr.
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

¹ Analyses by the author.² The sodium carbonate and bicarbonate, together with any combined water, constitute the natron proper, the other ingredients being impurities.

MODERN NATRON FROM EL KÂB¹

	1	2	3
	%	%	%
Sodium carbonate ²	13·6	13·3	11·0
Sodium bicarbonate ²	9·5	2·0	1·5
Sodium chloride	54·6	12·3	57·3
Sodium sulphate	11·4	70·2	29·4
Water, free and combined	4·7	tr.	0·4
Matter insoluble in water	6·2	2·2	0·4
	100·0	100·0	100·0

¹ Analyses by the author.

² The sodium carbonate and bicarbonate, together with any combined water, constitute the natron proper, the other ingredients being impurities.

ANCIENT NATRON FROM TOMBS

	1	2	3	4	5	6	7	8
	%	%	%	%	%	%	%	%
Sodium carbonate ¹	16·1	10·7	9·2	36·9	94·0	35·7	84·7	73·8
Sodium bicarbonate ¹	10·7	11·9	6·3	8·3				
Sodium chloride	25·2	18·2	39·3	9·9	0·5	39·5	1·5	13·0
Sodium sulphate	27·8	12·4	13·2	33·9	5·5	24·8	13·8	13·2
Water, free and combined	8·7	19·8	6·8	5·6	—	—	—	—
Matter insoluble in water	11·5 ²	27·0 ³	25·2	5·4	—	—	—	—
	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0

Nos. 1 and 2. From the tomb of Yuya and Thuyu (XVIIIth Dynasty). See J. E. Quibell, *The Tomb of Yuaa and Thuiu*, Cairo Cat., pp. vi, 75-7. Analyses by the author.

No. 3. Found in a vase at Thebes (XVIIIth Dynasty). Analysis by the author.

No. 4. From near the tomb of Ipy at El-Deir el-Bahari (XIth Dynasty). See H. E. Winlock, *The Egyptian Expedition 1921-1922*, in *Bull. Met. Mus. of Art*, New York, II, 1922, p. 34. Analysis by the author.

Nos. 5 to 8. From the tomb of Tut-ankhamûn. See A. Lucas, *Appendix II*, pp. 178-9, in *The Tomb of Tut-ankh-Amen*, III, Howard Carter. Analyses by H. E. Cox, for the author.

¹ The sodium carbonate and bicarbonate, together with any combined water, constitute the natron proper, the other ingredients being impurities.

² Chiefly sand.

³ A mixture of sand and sawdust.

EGYPTIAN BLUE FRIT
(Coloured by a Copper compound).

	1	2	3
	%	%	%
Moisture	1.6	—	—
Silica	57.2	63.4	70.0
Copper oxide	18.5	19.5	18.3
Oxides of iron and aluminium	0.8	—	0.3
Lime	13.8	14.4	9.4
Magnesia	0.5	—	—
Potash	nil	1.2	} 2.0
Soda	7.6	0.9	
	100.0	99.4	100.0

No. 1. XIXth Dynasty. Analysis by the author.

No. 2. Specimen prepared by Laurie, McLintock and Miles in imitation of the Egyptian material. *Egyptian Blue*, in *Proc. Royal Soc. A*, 89 (1914), pp. 418-29.

No. 3. J. K. Crow, *Report on Samples of Colours scraped from the Monuments*, in *Annales du Service*, IV (1903), pp. 242-3.

EGYPTIAN BLUE FRIT¹
(Coloured by an Iron compound)

	%
Silica	97.0
Oxide of aluminium	0.3
Oxide of iron (ferrous)	0.6
Lime	0.3
Magnesia	0.4
Potash	tr.
Soda	1.4
	100.0

¹ From Cairo Museum store : provenance and date unknown : analysis by J. Clifford.

POTTERY CLAY FROM BALLAS¹

	%
Silica	34.8
Oxide of aluminium ²	20.6
Oxide of iron ³	6.1
Oxide of phosphorus	1.1
Lime	12.7
Magnesia	0.4
Potash	1.0
Soda	1.3
Sodium chloride	1.0
Carbon dioxide	8.7
Sulphur trioxide	tr.
Water	12.7
	100.4

¹ Analysis in the author's laboratory.

² Containing a very small proportion of oxide of titanium.

³ The iron was all in the ferric condition.

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